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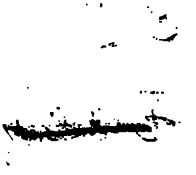

DR. J. F. JENCKEN'S WORKS.

VOLUME FIRST.

" Wär nicht das Auge sonnenhaft,
Wie könnten wir das Licht erblicken?
Lebt nicht in uns des Gottes eigne Kraft,
Wie könnt uns Göttliches entzücken?"—GOETHE.

TREATISES

ON

LIGHT, COLOUR, ELECTRICITY,

AND MAGNETISM.

BY

JOHANN FERDINAND JENCKEN, M.D.

TRANSLATED AND PREFACED BY HISTORICAL AND CRITICAL ESSAYS,

BY

HENRY D. JENCKEN,
Barrister-at-Law, M.R.I., F.R.G.S., &c., &c.

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TO

MRS. MARY HENNINGS.

UNTO whom else could I dedicate the works of my revered parent but to you, for it is to your untiring diligence, to the labour of forty years of your life, which you devoted to the recording of his works, that we owe the existence of the treasury of thought, of learning, now in your hands—the philosophical, the scientific products of his creative brain.

The manuscripts are all in your hand-writing. It was to you he dictated all he had garnered in from the inner resources of his mind. The voluminous notes culled from the works on sciences, on metaphysics, of the past, of the present—you made. The mere perusal of these required not a few years, but two score of years. A whole library of books on every subject of interest, you have studied, and

with unconquerable perseverance compiled, collected, arranged the material. The result of your life's labour, the products of my father's untiring industry, are now all mine, but subject to the condition that I make use of this treasury. I accept the trust, burdened with a promise on my part, to complete that which your strength will not permit, namely—to publish his works in both languages; systematise, arrange the material before me, and render his writings to the public in a more comprehensive form.

The deprivation of sight, for his eyes were closed for nearly thirty years of his life, gave to his mind a tendency to avoid the accumulation of facts. He eliminated with care all extraneous matter, confining his attention to that which was most essential. This, however, gave to his style of writing an aphoristic character, a habit of plunging *medias res* into the subject-matter dealt with; thus most of his writings necessitate a preface—an introductory statement of what essentially belongs to the subject treated of. This defect you had proposed to yourself to remedy. I know your resolve: you purposed gradually to collate and collect from all the vast material in your possession the most essential portions, and then to arrange and publish the works of your late friend;

but age has stepped between, and now, in your eightieth year, how could this be possible?—how could I allow this? Sight, strength fails; the eightieth year, with its silvery ray of a new morn of future life fondling your temple, does not permit of work such as you contemplated. You have, hence, allowed me to step forward and accept the charge. And this task I cheerfully undertake. I accept it as the inheritance of my father—the glorious, intellectual gifts he handed me when last we parted, to meet again beyond the grave. I accept it, at your hands—from you, to whom I owe so much. From my earliest boyhood to the present hour you have instructed, guided, and encouraged me. As oft as my will and strength would fail, you have stood by my side, roused the reluctant soul to farther efforts, to higher aspirations! What less could I do than complete the work you have devoted your whole life to; and had I no other motive, I would accept the charge in gratitude for all you have done in aiding in the intellectual work of my parent during thirty years of blindness, a deprivation which made the presence of a friend, devoted as you are to science, all but absolutely necessary; and without whose aid, his mind would not have been supplied with the material necessary for the creation of

thought. More I cannot say; my indebtedness to you is so great I have no language that will express it.

Your grateful and attached friend,

HENRY D. JENCKEN.

NORWOOD, *January*, 1869.

CONTENTS.

PAGE

DEDICATION, - - - - - - - - - - - v

PREFACE, - - - - - - - - - - - xiii

List of Works of Dr Jencken, - - - - - - xxviii

Concluding Remarks, - - - - - - - - -

CHAPTER I.

HISTORICAL AND CRITICAL ESSAY ON LIGHT FROM THE EARLIEST PERIODS TO THE END OF THE SIXTEENTH CENTURY, - - 1

Ancient Traditions—Greek School—Pythagoras—Empedocles—Plato, - - - - - - - - - - 4

Aristotle: His Classifications and Theory of Light and Shade, 7

The Roman School: The Absence of Artistical Powers, - 7

Pliny—Lucretius—Seneca, - - - - - - - - - 8

Alhazen the Arab and his Discoveries, - - - - - 10

PART II.

Roger Bacon: His Theories and Inventions, - - 10

Avempages and Averroes, - - - - - - - - 12

Vitello the Learned Pole, - - - - - - - - 12

Transition Period—Italian School, - - - - - 13

Antonius Thylesius, Simon Portius, Julius Cäsar Scaliger, 14

The Paucity of Invention of the Alchymists, - - - 15

Theophrastus Paracelsus: His Theory of Light, - - - 16

Bernhardinus Telesius—C. Cardanus—John Baptist Porta, - 16

Close of the Sixteenth Century. Giordano Bruno: His Death, his Philosophy, - - - - - - - - - 17

Francis Bacon: His Theory of Inductive Reasoning, - - 18

Recapitulation of the Greek Theories, - - - - - - 19

CHAPTER II.

PAGE.

THE DISCOVERIES OF THE SEVENTEENTH CENTURY, - - - 21
Introductory Remarks. The Effects of the Reformation on the Advance of Science, - - - - - - - - 21
Johann Keppler, - - - - - - - - - - 22
René Descartes—Law of Sines, discovered by Snellius - 23
Law of Colours—Theory of Luminiferous Globules—Theory of the Rainbow, Galileo Galilei - - - - - - 26
Athanasius Kirscher—Isaac Vossius' Theory of Emission of Rays, - - - - - - - - - - - - 28
Francis Maria Grimaldi—Coloured Fringes and Inflection of Light, - - - - - - - - - - - 29
Christian Huyghens—Discovery of the Undulatory Theory, Luminiferous Ether Waves, - - - - - - - - 30
Hooke, Father Pardies, Nicolaus Malebranche, - - - 31
Isaac Newton—Emission Theory, Experimentum Crucis, Homogeneous Light, Heterogeneous Light, - - - - 33
Dr. Thomas Young—Development of the Undulatory Theory, 34
Fresnel's Theory, - - - - - - - - - - 35
Polarisation of Light—Malus, his Discoveries—Laws as Explained by Brewster, - - - - - - - - - 39
Coloured Rings in Uniaxel Crystals—Fifth Rule of Fresnel's Theory—Sir David Brewster's Theory, - - - - - 42
Dr. Wollaston's Dichroism, - - - - - - - 42
Malus' Polarisation by Reflection, - - - - - - 43
Dipolarisation—Arago, Fresnel, Biot, - - - - - - 45
Early Objections to the Undulatory Theory, - - - - 47
Summary of Opinions on this Theory, - - - - - 49

CHAPTER III.

THE EMISSION THEORY—
Isaac Vossius *first suggests this idea*—Reasons Against this Theory, - - - - - - - - - - - - 51
Antonius Lucius, - - - - - - - - - - 53
Goëthe's Experiments and Refutations, - - - - - 54
LIGHT AND SHADE THEORY—
Antonio de Dominis—Aristotle's Theory, - - - - - 57
Goëthe, Farbige Schatten, - - - - - - - - 61

PAGE.

SUMMARY OF THEORIES—
Spectrum Analysis—*Frauenhofer*, - - - - - 62
Solar Eclipses, - - - - - - - - - - 65
General Reasonings on the above Facts, - - - - 67

CHAPTER IV.

Resumé of Dr. J. F. JENCKEN's Theory, - - - - - 71
Summary of Laws laid down by him, - - - - - 75
CONCLUSION, - - - - - - - - - - 77
Note on Theory of Twinkling of Stars, - - - 84
TREATISE ON THE EYE (*Note to page* 72), - - - - 93

TRANSLATION OF DR. J. F. JENCKEN'S TREATISE ON LIGHT AND COLOUR, 1837, - - - - - - - - - 107
Definition of Light, - - - - - - - - - 108
Dream Images, - - - - - - - - - - 110
Newton's Theory Refuted, - - - - - - - - 113
Dioptrics, Katoptrics, - - - - - - - - 119
The Solar Spectrum, - - - - - - - - 122
Prism Colours, - - - - - - - - - 128
The Rainbow, - - - - - - - - - - 132
TRANSLATION OF TREATISE ON LIGHT AND COLOUR (1852-1853) - 136
Philosophical Reasoning on the Properties of Light, - - 148
The Rainbow a Prismatic Phenomenon, - - - - 157
Prismatic Colours, - - - - - - - - - 160
Properties of Crystals, - - - - - - - - 161
TREATISE ON LIGHT, 1862—Odic Light, - - - - - 170

HISTORICAL AND INTRODUCTORY ESSAY TO DR. JENCKEN'S TREATISES ON ELECTRICITY AND MAGNETISM. By H. D. Jencken.

PART I.—ELECTRICITY.

Introduction—William Gilbert, 1600 - - - - - 177
Otto Guericke, of Magdeburg, - - - - - - - 178
Hawkesbee, 1709, - - - - - - - - - 178
Dufay, 1735, - - - - - - - - - - 178
Discovery of the Leyden Jar, - - - - - - 179
Benjamin Franklin—Positive and Negative Electricity, 179

PAGE.

Snow Harris, Canton: their Discoveries, - - - - - 179
M. Coulomb: His Theories—Force Inversely as the Square of Distance, - - - - - - - - - - - 180
Prof. Ohm—Galvani—Volta—Christian Oersted, 1820, - 182
Discovery of Action on Magnetic Needle, - - - - 183
Schweigger—Invention of Galvonometer, - - - - 184
Thermo-electricity—Professor Faraday—Discovery of Diamagnetics, - - - - - - - - - - - 184
Dielectrics, - - - - - - - - - - - 185
M. Æpinus—Austral and Boreal Fluids, - - - - 186
M. Dufay—Statical Fluids, - - - - - - - 187

PART II.—MAGNETISM.

Definition of word Loadstone, - - - - - - - 189
William Gilbert: His Theories—Dr Halley, Theory of Magnetism, - - - - - - - - - - - - 190
Professor Hansteen and Æpinus—Discovery of Magnetic Regions in Siberia, - - - - - - - - - 191
Hansteen's Theory of Sun-power Creating Magnetism, - 193
Gauss' Theory, - - - - - - - - - - - 194
Faraday and Grove's Theory—Dynamic Theory of Grove, - 195
Summary of Dr. Jencken's Theory, - - - - - - 197

ELECTRICITY AND MAGNETISM. By Dr. Jencken (translated by Mrs. Hennings), - - - - - - - - - - 203
Polarity: Direction and Contradirection, - - - - 206
Definition of Electricity and Magnetism, - - - - 210
Oersted's Theory, - - - - - - - - - - 232

PREFACE.

THE Translation of Dr. Jencken's Treatise on Light and Colour has been preceded by an introductory historical and critical essay. This necessarily takes the place of a Preface: it preludes the subject matter treated of; and such being the case, I should have but little to add, but for the fact that the present volume constitutes only the first of a series I intend to publish. His works, of which I furnish a list, embrace a great number of subjects too comprehensive in their range to be dealt with as a whole—the material being too vast to be employed, unless in separate parts. It is this that has prompted me to select one subject matter, and exhaust that in the first instance, and then proceed to others; and, in their turn, endeavour to grasp their meaning, prefacing the translations of each treatise by an essay, and an analysis of the writings of other authors, and a comparison of their views with the theories of Dr. Jencken, accompanying the essay by explanatory notes and suggestions of my own. This task I have unhesitatingly undertaken,

being fully aware of the difficulty the condensed style of the writing of my father imposes upon the reader. The historical part of the introductory essay furnishes an outline of the progress and development of the science treated of. The material for this I have in part taken from Whewell's History of Inductive Sciences; in part from Goëthe's Farbenlehre; and farther from the writings of Herder, Tennemann, Schwegler, Schlegel, and the Historical Sketches of Lewes' Biographical History of Philosophy; the scientific and mathematical portion, from Sir David Brewster's works, and those of M. Fresnel, M. Arago, of Herschel (Sir J.), Mrs. Somerville, and Grove, whose name I always mention with pleasure; and last, but not least, from the works of Faraday and Professor Tyndall. I refrain from recapitulating the list of authors I have consulted, studied, and quoted from; and mention these names only as a guide to those who may feel inclined to follow up the inquiry, and master the science of Light in all its bearings.

Having thus far explained the method I intend adopting, I must now deal with the writings of Dr. Jencken. The list of works published and in manuscript, are nearly all in the German language, with the exception of his translation of Herder's Cid, and his treatise on Religion and Philosophy; and the difficulty I have in arranging them, arises

from the habit the author had of jotting down his ideas in a fragmentary, irregular form; not unlike Leibnitz, who had the unconscionable cruelty of committing many of his most brilliant ideas to the charge of a letter addressed to a friend. This renders the arrangement more than ordinarily a task of extreme delicacy, and the translations will necessarily have to appear in disjointed parts. To remodel his language, reproduce from my own mind his thoughts, I dared not venture; hence, with all these defects, I have preferred rendering the translations intact, prefacing each subject matter with an historical and critical essay, and of which the one preluding this volume constitutes the first of a series.

The writings of Dr. Jencken I have classed into three groups.

First, his philosophical writings, which I have designated the crowning efforts of his mind. These are very numerous, commencing with his *Skitze eines Natur Systems*, a treatise published in 1828, and concluding with fragmentary pieces, dictated to his friend as late as 1864, and immediately before his death.

The fundamental ideas of his philosophy are powerfully conceived. *Being* and *Becoming to be* (Seyn und Werden) represent the central and peripheral of the Infinite, all perfect each, mediated by endless variety, omnifoldness, manifoldness, as

essential attributes of the Deity, resulting in perfect harmony (the praestabilitirte harmonie of Leibnitz).

Having exhausted metaphysical material, he grapples with theology; and his theory of existence—*supernal spheres* of higher and highest self-conscious beings, aiding, guiding, attracting us, as if though by mere friction of particles, onwards and upwards in never-ending ascent, is a glorious truth which he has enunciated! He further says, that the Godhead mediates its laws of moral excellence through the superior intelligence of higher, of further developed beings; that the thoughts of God, being absolute realities, are absolutely creative—hence the *freewill* of a created being, and the *will of God*, can only be conceived as co-existing by the presence and protection of an infinite mediation. This mediation is accomplished by supernal beings, in ever higher ascent of further progressed development. Freewill is based upon the law of infinite possibility.

His philosophical theories, as applied to physical sciences, are equally comprehensive, and I will, in enumerating his writings on sciences, sketch in outline the salient ideas that distinguish their characteristic. Each branch of science would necessitate a thorough consideration, so as to present a comprehensible picture; to do this I have at present no space. Suffice, if I state his leading idea, viz., that

the law of polarity underlies all the formative laws of natural kingdoms.

The second group of his writings is composed of the works on scientific subjects. The range of subjects included in his writings published, or sketched in fragmentary pieces and notes, is wonderfully comprehensive. Every topic of importance has been dealt with, and I know of no other parallel instance, unless it be in the essays and short pieces of Bacon's writings. The *Natur Parallelen*, and the collateral sciences necessarily accompanying a work of such magnitude, must be mentioned first. Here he develops his ideas of the Peripheral and Central, Negative and Positive, Reproductive and Irritable, as fundamental laws manifesting themselves in all the forms of nature; and the classifications invariably point to a dualism, a polarity, primary state, and a concentration into an apex point, and further progress from this last point of union.

The medical works I leave apart. Fortunately, my brother, Dr. Jencken, of Kingstown, has accepted to deal with these, when he publishes his own writings on medicine.

The third group is composed of his treatises on historical, political, moral, and philosophical subjects, to which may be added his great works on *Solar Worship*, and *The Creative People of Antiquity*, both of which he has left to me to complete; and, finally,

his treatises on Numbers, Geometry, and Proportions of Bodies, and his Definitions, rendered in the form adopted by Goëthe in his Xenien.

Having thus far disposed his writings into distinctive groups, I will now render them in their chronological order, accompanying them with explanatory comments.

His first published work was a theological treatise, "*Das Evangelium Johannes*" (1827). This little volume is highly instructive, and the difficult questions of the ὁ λογος are mastered with great skill and show of classical power.

The next publication was that of his translation of Herder's Cid into English verse (1828). Then followed—

Bemerkungen über Cholera Morbus—(Remarks on Cholera). 1831.

After which, in order of date—

Translation of Shakespeare's Hamlet into German.
Skitze eines Natur Systems—(Sketch of a Natural System).
My Hobby. 1832.
Die Schöpfung—(The Creation).
My Hobby; a series of Essays.
Zur Naturkunde—(On Natural History). MS., 8 vols.

During the period from 1837 to 1852, he wrote and in part published—

Blick und Wort, und Neue Protestantismus. 1850. 4 volumes.
Das Bildende Volk des Alterthums—(The Creative People of Antiquity).

Zur Heilkunde—(Theory of Therapeutics).
One Volume of Poems. 1850.
Domestic Medicine. 1842.
Practice of Medicine. 1842-1845.
Arzeneikunst—(On Medicine). 1852.
Natur Philosophie—(Natural Philosophy).
Natur Parallelen—(Parallels of the Natural Kingdoms).
[A work of great originality, rendered in outline only; nevertheless laying the foundation to a perfectly new system of arrangement of the Natural Kingdoms, and forming a continuation to the "Naturkunde," 1840.]
Parallelen des Organischen Bans—(Parallelisms of Organic Structures).
Pflanzenkunde—(On Botany).
Geologisches—(On Geology).
Das Wasser—(On the Formation of Water).
Zoologie—(Zoology).
Mineralogie—(Mineralogy).
Bergzüge—(On Mountain Ranges).
Der Neue Protestantismus—(The New Protestantism). Partly published in 1852.
Gott and Welt—(God and the Creation).
Solar Religion—(Solar Worship). In MS.

And, finally, his philosophical works, which, rendered in their chronological order, are as follows :—

Treatises on Natural Philosophy.
Abhandlungen—(Essays and Notes). In MS.
Philosophische Abhandlungen—(Philosophical Transactions). In MS. 1852-1857.
Philosophie und Religion—(Philosophy and Religion). Published in 1853.
Philosophische Fragmente—(Fragmentary Writing on Philosophical Topics. All in MS., and published in 1860-64.
Zum Spiritualismus—(On Spiritualism). In MS.

Exclusive of these works, and which are nearly all in German and in MS., Dr. Jencken has written a series of Essays—fragmentary in part, and accompanied by marginal notes—on every subject of interest. These include—

Kritik über Goëthe's Faust. Zueyter Th.—(Comments on Faust: Second Part. Goëthe.)
Bemerkungen über Drayson—(Remarks upon Drayson).
Seherin von Prevorst—(The Seeress of Prevorst).
Uber Musik—(On Music).
Electricität Magnetismus—(Electricity Magnetism).
Chinesische Urkunden—(Chinese Records).
Bemerkungen über Windischmann—(Notes on Windishmann).

The poetical works of Dr. Jencken include poems, occasional pieces, several translations, and, lastly, the well-known translation of Shakespeare's plays into German; and with the mention of these I conclude the list of his writings, the product of fifty years of study and thought. From this great treasury of learning, I propose to myself to select those, in the first instance, which I consider to constitute the crowning efforts of his mind. These are contained in his philosophical works. Of equal merit are his "*Natur Parallelen*," replete with original thought. The classification of animals is singularly powerfully conceived; the groupings (as already named) are upon distinctive laws he has laid down, and which are nearer the truth of Nature's working than the classifications given by Buffon, Cuvier, and

those who have adopted their mode of arrangement. He contends that the irritable and reproductive constitute the polaric extremes of the animal kingdom, the union of these being represented in the higher organic forms of animal life, culminating ultimately in man.

In *Botany*, his classification of plants rests upon principles taken from this fundamental law, which pervades all the natural kingdoms—the law of dualism; of polarity; of central and peripheral—which rules dominant in all the created forms of fauna and flora, of mineral and geological formations; unfolds its presence in obedience to one all-constant creative act, the manifestation of polaric development; and culminates in an apex point of concentration, of higher, more complex forms.

His medical works are masterpieces of inventive, brain-creative power. The *Arzeneikunde* (1850) and *Heilkunde*—what a fund of thought they contain! The works upon Practice of Medicine, Domestic Medicine, his treatise on Cholera (1831)—*Bemerkungen über Cholera Morbus*—and Theory of Medicine, are each of them replete with suggestive thought; and it is with pleasure that I notice that Dr. Ferd. E. Jencken,* of Kingstown, is following in the foot-

* Dr. Ferd. E. Jencken (of Kingstown, Ireland), M.R.C.P., London, author of a treatise on *The Cholera*, On *Vaccination*, *Cattle Plague*, &c., &c.

steps of his father, and is preparing for the press a complete and comprehensive work upon medicine, of sufficient extent to grasp the whole philosophical questions, as sketched out by his parent, and embodying his own experience, the result of twenty-five years' practice and study.

But it is in the philosophical writings of Dr. Jencken that I seek for the heart of his intellectual strength. His mind appears to unfold with irresistible, all but intuitional, force, whenever he treads upon philosophical ground. Possibly the inward intellectual vision was proportionately the more intense, as his outward sight became dimmed, closing in upon him in a long night of physical darkness. But this very introvision has given to his language a quaintness, a curtness, rendering the perusal of his writings difficult. Or it may be, that the act of creating original thought, renders the employment of a well-arranged style, and use of an easy, fluent language, difficult, if not, perhaps, all but impossible. Be this as it may, his style is not easily followed: too condensed, aphoristic—to suit the training of ordinary intellectual comprehension.

I am now assuming that the reader possesses a complete mastery over the German, and can study his writings in their original language; but who, except the native-born, can grasp the wonderful expansiveness of the great German language, with

its radical words, augments, and inflexions — its capability of forming composite words? This insuperable difficulty I well understand; hence I have resolved to render his writings in English; to translate such portions of his works as I may deem desirable; preluding, where necessary, by an historical, critical, and explanatory essay, accompanied by notes collected by myself, or copied from those made by Mrs. Hennings.

But to translate his works necessitated a thorough revision. Subjects of interest have been repeated, re-written by Dr. Jencken; and the great difficulty I had to contend with was that of eliminating his ideas, without repeating that which had already been said. This task I found to be immeasurably increased by his style of writing. He invariably plunges "*medias res*" into the subject matter he deals with, presupposing a thorough acquaintance with the facts of the science treated of, and the groundwork upon which he rested his theories. No doubt, his blindness induced this method of thought;—all extraneous material had to be flung aside, only that which was essential retained. But this system ill suits the reader. Be the acquirements of man's intellect what they may, facts want brushing up; and the branch of learning once familiar to the mind, requires, to make it enjoyable to the student, replacing before his intellectual vision. It is this defect of the

writings of Dr. Jencken I have proposed to myself to remedy. Hence I shall prelude each volume with an historical and critical essay on the subject matters dealt with. By adopting this method, I may be of some use to the learned reader—may save him the trouble of looking up points as they arise. To the less learned reader, I hope by these means to render the perusal possible, and induce him to glance at the pages; at all events, enable him to take an interest in the study of the history of the great struggle that high order of intellects have encountered in their efforts to grasp the laws of nature.

The first volume of my father's works will contain his treatises on "*Light and Colour*," translated from the German by myself. These treatises I have, conformably to my resolve, introduced by an historical sketch of the progress of the knowledge of the laws of Light from the earliest periods to the present day. concluding with an *exposé* of the views and ideas I have formed for myself. This I render with diffidence, and would not have done so, but for the request of Mrs. Hennings, to whom I am so deeply indebted for the aid she has rendered in my intellectual labours, and at whose desire I publish my theories together with those of my parent.

In furnishing historical and introductory essays as prefatory to the author's writings, I have had, however, another object in view, apart from that

already stated. Dr. Jencken is so singularly original in the line of thought he adopts, that to understand the distinctive character of his writings, it becomes necessary to render a *comparative* history of what others have said. The essay prefacing *the first volume* of the translation of his works is written with that object in view. I have endeavoured to ascertain what others have thought, the advance they have made; and then to show in what respect Dr. Jencken's claim to a point beyond is sustainable or not.

It now rests with me to explain why I have selected the subject of *Light* as introductory to the writings of Dr. Jencken I intend to translate and publish. The subject of Light has been all but exhaustively dealt with, and great originality of thought and varied suggestiveness characterise these treatises; nevertheless they rank only as a third in his works. Why, then, with his great philosophical writings before me, have I given my choice, in this first instance, to the Physical Science of the Laws of Light? This needs explanation. I will answer.

The great task I have undertaken has induced a hesitancy, a reluctance, to publish before the manuscripts have been thoroughly revised and corrected. This would involve time and labour, eyes and brain-work. The numerous occupations I am engaged in, the call upon my time, professionally and other-

wise, is so great, that I have not had the physical strength to accomplish the work with the care the writings merit; hence I have deferred translating the "*Naturwissenchaft*" and Philosophical Writings, until I am more at leisure. The philosophical works I intend to grapple with shortly, and so soon as the translations are completed, to publish with these a comparative history of philosophy, now in the course of preparation. But a work of that magnitude exacts intense application, endless reading, and collating; and a year or two may pass before it is fit for the press. I regret the delay, but it is unavoidable; for, I repeat, the philosophical theories of Dr. Jencken stand forth with such originality, power, and variety of conception, they merit being published. To do them justice, however, it will be necessary to show what others have thought, and to compare the points in advance he has gained with those which others have attained. This is a task I am grasping; when I have mastered it, the publication of his philosophical writings will not be deferred for a day. But the *Natur Parallelen* (on *Natural Philosophy*) need even greater labour to prepare them for the press. The systems he has founded, are only given in outline. The foundation, it is true, has been laid by a master-hand, but the completion of the edifice has been left to others. To master the vast amount of facts comprised in the study of

Natural History, the science of the forms of organic and inorganic nature, would compel the student to learn before he could venture to classify. This is at present far beyond my reach. I should require the aid of others—of scientific men capable of handling the subject as a whole. Possibly the future may bring me this assistance; but for the present I dare not venture to publish a work of such magnitude.

Nevertheless a commencement had to be made; I had to select some one of the writings, translate this, and, conformably to my plan, prelude the work by an historical and critical essay. I have selected the treatises on "*Light and Colour*," and in doing so, have been prompted in my selection by several reasons.

The study of the laws of Light was a favourite subject with Dr. Jencken. Goëthe's great work on the "Farbenlehre" he had studied with untiring assiduity; added to which, he well knew the high importance of the knowledge of the property of Light. "Tell me," he often repeated, "what Light is, and I will solve the mystery of the action of the physical dynamic forces." The great question of the day—what all this means, this translation of forces, the pulsate of an unseen ether wave undulating through space, the comprehension of which has occupied the brains of Young, Fresnel, Faraday, and Brewster—had fully rivetted his attention. The

result of his meditation I render in the translations now published.

It further occurred to me that a treatise on Light would form a suitable introduction to physical sciences, and which I primarily propose to deal with. Photography has brought home to every hearth the result of a scientific research, in the record of the faces of our nearest friends. The acquaintance with the subject is so general that even the press can afford to devote column after column to the description of the Solar Eclipse, of Meteor and Spectro Analysis;* and it is pleasurable to notice with what care and thoroughness of thought the able writers of these articles have handled the subject.

Following these translations of his Treatises on Light, I intend to publish those on "Heat," "Electricity," "Magnetism"—the correlates of Light, as Grove designates them—thus completing the circle of physical dynamic forces.

The Treatises on these subjects are fragmentary, and to a certain extent incomplete; nevertheless, they are replete with suggestion. On each of these subjects his ideas are singularly original. I cannot refrain from rendering some of his definitions; they

* The *Times*, *Saturday Review*, and *Daily News* have published a series of highly scientific and able articles on "Meteors," Solar Eclipse, and the Spectro Analysis (See September October, and November Numbers, 1868.)

give in a few words his theories. Electricity, he tells us, is created. "Whenever force pours forth concentratively, in polaric unfoldment and manifestation of Light, it then produces Electricity." "Electricity polarises at each point of transmission by a return into the primary poles of expansion and contraction, accompanied by Light, and Heat, and Magnetism—peripheral attraction and the inward contraction being represented by + and —."

Of Heat and Cold he says—"Expansion and Contraction, finer material transformation of force approximating to light and ether. Cold is comparable to rest, heat to motion, to inward combination, and outward combination." *

But I must not forestall; time enough when I render his Treatises in the English language, to give his definitions. These subjects are all comprehensive, and must be dealt with accordingly.

It is of high concern to ponder over the advance made. The great interest evinced by the public in purely scientific subjects is so marvellous a change, when compared with the stolid indifference of the past. What has produced this change, and fitted for the reception of intellectual food the minds of the many, who in years past never troubled themselves with science; and with what was then

* Dr. Jencken—Introduction to the Work on Medicine, 1850.

stigmatised as the "incomprehensible"? I have a theory of my own to explain this. A great revolution is working its way in the intellectual organism of the civilised races. This mutation is more than the product of the joint efforts of men in one direction for intellectual advance. Railways, steam communication, are intermingling races. A new generation has sprung up on the American continent, differently organised, with, if I may be allowed to say as much, greater capacities than were possessed by their European ancestors. The American, with the large lower jawbone—a prominent characteristic of the race—points to a transition, an onward progress, of the human type, accompanied by mental capacity prepared to keep pace with the iron energy of his race, —the transition is always crude in its form, but undoubtedly the advance is there.

The improvement, though slower in its progress, is, nevertheless, making its way in Europe. Time-honoured authority is yielding to the advent of new ideas. Materialism is shaking its head at theories that pre-suppose an unseen, unweighed agency, and which our coarser outward senses cannot grasp, cannot touch. The closed gates of Science have been invaded by unseen guests. An undulatory wave is said to have pulsated through space, and Light, we are told, has arisen from the bosom of the Night to greet mankind. Another throb, and

Heat—the great motor power—uplifts his giant head; and another undulation, and Electricity, Magnetism—those mighty forces of Nature—arise from the depths of her inner laboratory, the Intro-world within. Strangers indeed! What right have they in the temple of Science? But there they are, carrying havoc into the camp of dull Materialism. The theories of Isaac Newton have been exploded. Light is no longer considered to be composed of seven divisible homogeneous rays; but Light is now conceived to be an undulatory wave motion, a mere vibration.

Facts fresh from nature prove the utter untenability of the conception of a perfect materiality of Light, and men accept this as a truth. Iron-gripped matter controlled by an imponderable agent, it is hard to believe, and yet so wondrously true. Materialists had need indeed to rub their eyes, and peer and stare at the unseeable.

Yet the *Unseen*, the *Unweighed Dynamic Agencies of Great Creative Nature*, are working their wonders all around us, and the thinkers of the age worship their presence and power in the heart-spoken language of men thoroughly in earnest for that which is true. Young, Fresnel, Biot, Brewster, Ampère, Faraday, and many more, have gone to the altar of these unseen powers of nature, and uttered their soul's prayer in new-born thoughts. The great men of the day

are doing the same. Every step in advance made, brings us nearer and nearer to the admission of an intro-existing, all-pervading ether world, permeating this ponderable nature we reside in. And Light! —what is it?—whence comes this swift-footed, ever-busy, never-resting messenger? From the *Intro Ether World!*

Torch in hand, Light stands on the threshold of another, deeper, inward-seated, physical, *real world*, the *intro-coexisting ether world*, that holds the, to us, material and ponderable in its all-potent grasp. And the luminiferous wave points, as they pulsate through space, herald the transition from the ether world within to the known forms of life. All nature acknowledges this, and the phenomenal life of the actual existing speaks forth in full-toned diapason the praise of this omnipresent creative law, the intro-coexisting ether world.

Light is dynamic, essentially dynamic, and therefore creative. It is the coefficient of a factor which is buried deep within the inner recesses of nature's laboratory. And it is because I ascribe to Light so important a character, that I may be allowed to say I did well in placing the treatise on Light and Colour on the first pages of the first volume of the translations of my father's works. The intro-existence is by no means a law first suggested by Dr. Jencken, nor by myself; it has been acknow-

ledged by the philosophers, ancient and modern, and worshipped in the traditional teachings of every race. The study of the laws of the unseen meets us in the intellectual advancement of every people. Those Lymbic realms Dr. Doherty speaks of in his work on Organic Philosophy, stand admitted as realities by physicists, philosophers, and theologians.

Materialism, in the narrowing sense it has been adopted by the present age, is being expanded, made to teach the laws of the non-ponderable. Not that I quarrel with this form of thought. Materialism has had its uses—by compelling the mind to seek for proof, it has driven us back upon the inductive process of step-by-step reasoning, compelled the understanding of phenomena themselves, and of what our senses have grasped; but in as far as Materialism only admits a ponderable, visible, to our senses appreciable, materiality, it has fettered inquiry, restricted the field of scientific research, and shut out the purer light of intellectual life.

Matter is a form of force. What this force ultimately is, cannot be solved by any known inductive process; but our reason can and does transcend the limits prescribed by our outward senses; and, by deduction, I can absolutely know that an inner and finer element—finer yet than the luminiferous ether wave of Huyghens, Fresnel, and Young—exists, which feeds, and supplies, and sustains the material, pon-

derable, and phenomenal. Light and its Correlates stand at the, to us, known portals of this material world, the threshold of the great physical transitions from one state to another—not a transition from one elementary condition of our materiality to another, but from one ether inner state to another intro state.

Life, organic life, is likewise on this boundary line. Wonderful the ephemeral, transitory character of all forms of life, of our manifold flora and fauna. The number of organic beings transcends calculation, and billions upon billions of animals are born and pass away, we know not whither. The human race furnishes alone three to four thousand millions of souls each century, which pass onward into a further developed state. What a world these ether spheres must be, to have space to hold these beings; to continue the forms of life—for nought is lost in God's creation. The indestructibility of the material Faraday pointed to, warns us of the ever-continuing presence of the once created. That the ether state is the permanent ruling condition of the created, a glance at our starred heavens teaches, without seeking for further evidence. The ratio of the diameters of solar bodies, and their distance from one another, the interstellar space, points to a law, if we could but decipher it, that would disclose one of the great mysteries which surround us—the mystery of the almost boundless interstellar ether-filled space.

Light, I repeat, stands at the portal of the Everlasting, *Intro-existing World*, heralding its presence in luminiferous vibrations of ether, carrying on their wave points the supplying stream that sustains life. Have I, then, done wrong in placing the treatise on Light on the first pages of my father's works? Its study is all important, leads to the comprehension of other laws, to the understanding of deeper-seated truths of more universal application, that underlie the coloured surface play of the, to us, visible and phenomenal.

With these remarks, I close my Preface. In the perusal of the treatises that follow, I claim the indulgence of the learned where I have failed, where my shortcomings have betrayed me. From the less learned, I ask a short hour's study, if only of the introductory part; not that my merit is such as to warrant the reading, but the subject matter is so glorious, so grand, I wish others to enter the sacred shrine, and gaze at its arched roof and painted windows. Assuredly, they will say with me, that the study of nature is indeed a hallowed privilege of the self-sentient soul.

AN

HISTORICAL AND CRITICAL

ESSAY ON LIGHT,

INTRODUCTORY TO THE TRANSLATIONS OF

DR. JOHANN FERDINAND JENCKEN'S

TREATISES ON LIGHT AND COLOUR.

BY

HENRY D. JENCKEN.

CHAPTER I.

An Historical Sketch of the progress of the knowledge of the Laws of Light, from the earliest periods to the end of the Sixteenth Century.

SOME apology may be needed for preluding Dr. Jencken's Treatises by an historical sketch of the progress of the knowledge of the properties and laws of Light; but this course has become necessary, from the fact of the *medias in res* method with which the author has, in his usual aphoristic style, handled the subject; added to which, the right understanding of the views and theories of those who have preceded us in any branch of science is highly instructive, and enables an easier comprehension of the actual advance made.

What the ancient Chinese had taught on the subject of Light, we can only guess at—their records are silent on this subject; and Windishmann,* in his History of Kings (five Books—the sacred writings of the Chinese) does not even allude to physical sciences. Yet, that this strange, early developed people must have had an intimate knowledge of the colorit of substances, their highly advanced technical art of dyeing fully confirms. India,† with its coloured cloths and shawls—the elegant textures the Hindoo wove

* Windischmann, Philosophie im Fortgange der Geschichte, Le Chow King, par P. Gaublir. 1778.

† Schlegel heilige Schriften der Indier. Tennemann's Geschichte der Philosophie, p. 43.

and dyed ages before the first dawn of civilisation had opened its eyes upon more western Europe—must equally have been far advanced in the art of colouring. The colouring processes of the ancients were, however, all tardy, accomplished by the slow chemical action of nature itself. Extreme neatness, cleanliness, was observed in the process; and, as is the case with all primitive people, technical art and religious rites went hand in hand.

Travelling farther west, to the banks of the Nile, we find the same advance in the art of dyeing and painting, which the mummy tombs reveal;* but in vain do we search for a scientific thought on the properties of Light. The allegory of the religion of these people speaks in wonders of the great phenomena of nature, Light. Their deities represent Sun and Dawn, and the coloured phenomena of nature—(the Isis and Horus child represent Sun and Morn);—but we receive from those days only the echo of veneration, as it arose from the breast of an infantine people; no positive statement of the knowledge they possessed.

It is not until we come to the Greek that we find any advance in the study of this most attractive, most marvellous, phenomenon of nature. It was the Greek who, either deriving his knowledge from sources hitherto concealed by the past, or receiving it from an inward power of his own mind, boldly made a step in advance, and propounded laws in his endeavour to grasp the understanding of the lumniferous properties of sunbeams.

At this threshold stands PYTHAGORAS. Let us hear what he has to say.

The surface of bodies, χροιά (says the school of Pythagoras), is coloured. This property is innate in all

* Athan Kircheri Œdipus Ægyptiacus. Sharpe's History of Egypt. Winkelmann, Gd. Ae.

substances; belongs to them as their own. Vision itself, like the function of all our senses, is a hot vapour emanation. Reflection of rays from a mirror he attributes to a return of the ray itself. The classification of colours he divides into "white, black, red, and yellow," as being the primary colours from which the others are formed.

Here, then, a first attempt to theorise—necessarily imperfect. But, nevertheless, with what intuitional grasp and power Pythagoras handles the subject!

Next in order of time is EMPEDOCLES. Of him we have firstly Theophrast's writings, and then those of Stobäus. According to this philosopher, the act of vision is accompanied by the aid of πορροι, or watery channels through which the inner eye, which contains a self-luminous property, a fire, is reached. White light is conveyed by this fire—the πορροι, or watery channels representing shade. This fire is in some individuals external—that is, beyond the eye itself; hence, as in animals, the eye can see in the dark. He also recognised the surface-coloured property of bodies; permanent colours as distinguished from evanescent colours. The πορροι of Empedocles must, however, not be understood literally. In dealing with the æsthetical, highly refined Greek, we must cast aside the narrowing, material signification our northern language gives to words, and treat language as essentially symbolical, æsthetical. A fluid presupposed a vessel it was contained in; hence these hypothetical πορροι. The ether element, as modern science terms it, was supposed to be enclosed in channels.

But if this rule applies to Empedocles, how much more so must it do in studying Plato, who, invariably with a feeling of reverence, approaches the truths of Nature. The συγχρίνειν and διακρίνειν he employs as expressive of the great dual act in the creation of all things—this putting together and resolving witnessed in every phase and function of life,

the breathing of nature in its systole and diastole of never-ending creation.

But before I proceed with Plato, a few words on Democritus, Epicurus, Zeno: it is so interesting to follow these great minds, and learn from their lips how the entrance was made within the precincts of the sacred shrine of knowledge.

According to Democritus, the act of seeing is an "*emphasis*." This emphasis occurs in the air itself; that is, the seen and seeing are compressed into a definite form, and vision results from this. Colour he regards as accidental, not inherent in matter itself.

The idea that colours are not part of matter, Epicurus confirms in his second book. They are, he tells us, produced by their position in reference to the eye itself.—Zeno designates colour as schemas of matter.

Plato, what has he to say? Not only did he grasp the theories of his predecessors, but advanced beyond, adding another law to those already understood: Colours are produced by a flame emanating from bodies, so constituted as to impress our sense of vision. White light contracts the vision; darkness holds it in a state of inactivity. He, too, recognised an inward fire in the organ of the eye; a power, but subjective in its action. The producing of colours by admixture he renders as follows:—If the luminosity be mixed with red and white, yellow is produced. Red and black commingled give purple; but when a burning interferes, the product is black.

Goëthe acknowledges these theories of Plato with unfeigned pleasure. Light and shade produce colour, says Plato; and Goëthe's theory is to that effect. The idea of opposites in the act of vision is also alluded to by Plato This theory was the leading thought of the period, and could have hardly been allowed to pass unnoticed.

But the originator and organiser of the theory of opposites is Aristotle. His treatment of the subject of light and colour is in accordance with this idea. Let us ascertain what he has to say, this great systematiser of natural phenomena.

Colours are, according to him, the product of light and shade. Their commingling in certain proportions produces the iridescent phenomena of nature. I can hardly refrain from rendering, in greater detail than I at first intended, the classifications of Comis,* and in doing so transcribe from Goëthe, whose extract of the writings of Aristotle I refer to. Simple colours are yellow, white, black; and these accompany the elements—namely, fire, air, water, and the earth. Air and water are intrinsically white; fire and the sun are yellow. The earth was originally white, but has become "tinged" by the presence of colours, produced by the agency of the sun; and in confirmation Aristotle appeals to the whiteness of ashes after combustion of wood.

Dark colour accompanies the elements in their transition from one to another. Absence of light is shade. Colours are produced farther by a κρασις, or a mixing; and herein is contained the endless cause of variety of colours—a list which it would be needless to enumerate. The undetermined colours appear to have fixed the attention of Aristotle, and these he attributes to the different combinations of light and shade. Artificial colours equally attracted his notice; these he allows to be created by the presence of a foreign substance. They enter into the pores of the matter they colour, and change its appearance accordingly.

The effect of boiling—an organic act of bodies—is to Aristotle of great importance. Hair, feathers, flowers, fruit, and the parts of plants generally, change their colour by a

* Farbenlehre Goëthe, tom. ii., p. 24.

process of "organic boiling." I only have space to note down the leading ideas: for farther detail I must refer the reader to the translations of Aristotle and Theophrast. I may, however, be allowed to render from Goëthe one passage as illustrative of the mode of thought of that period. Aristotle says:—

"Like as colours are produced by the commingling of white and black—light and shade—equally so the taste by the mixing of sweet and bitter, and that in their relative proportion, it may be in number or in movement. Pleasant and agreeable tastes are dependent on a certain proportion of numbers. Similarly, colours are related to one another; for of each we have seven, including, as by right we ought, the φαιον. Hence it follows that yellow belongs to white, like that sweet is affixed to the fatty taste. The red, violet, green, and blue lie between the white and the black; and as to the rest they are placed between these two."*

Thus much of translations. That which attracts us in the Greek is his æsthetical reasoning, which all but by intuition led him step by step to observe, with unparalleled acumen, the phenomena of nature. Marvellous how easily he strode over the ground! Without aid, unassisted by the wonderful mechanical apparatus of the present day, he collated as he observed, experimentalised upon and grouped phenomena together with exquisite skill, meriting all that Goëthe says of him:—

"The depth of intuition, a quick perception of the present, mathematical profoundness, physical minuteness, height of reasoning powers, acumen of the understanding, a mobile yearning of the phantasy, an enjoyment of the sensuously seen,—nothing of all this ought to be wanting

* Farbenlehre, tom. ii., p. 22.

to fit an artist to appreciate a work of art, and these qualities the Greek prëeminently possessed."*

That colorit, that painting, must have been well understood in Greece, needs hardly affirming. The laws of the perspective were known to them; and we find Eschylus learning the art of decoration from Agartarchus, and Anaxogoras teaching the principles of the lineal properties of light. The nomenclature of the Greeks, in itself, shows how far advanced they were. Assuming, as their theories did, that all colours were produced by light—and they use the term μιξις to express this idea—but with that sensitiveness of an inborn principle, the thought of a κρασις συνκρασις is at once adopted, expressed in these words, which denote a power of selection, a change wrought by this commingling. A fixed sterile colour, they well knew, does not exist; the line of mergence is constantly present on the borders of the coloured field. Colours are—*plenum*, *saturum*, καταχορις; *suasum*, πεπεισμένον, &c.; *profundum*, βαδο. They have many qualities, and for each a word expressive of its meaning was created, expressly adapted to render the physical character of the colour.

I must now pass on to the less refined, less æsthetic, Roman. The physical sciences had but slight attraction for the conquerors of the then known world, unless they subserved the purposes of war and trade, or satisfied the coarser tastes of their more barbarous luxury. Colouring, as an art of decoration suitable to embellish the palaces of the great, was studied, and in this branch considerable advance made. Pliny gives us an interesting account of the methods practised in those days, accompanied by an historical sketch of the progress of that special art of

* Farbenlehre, tom. ii., p. 30.

painting. Shadow tracings, according to him, were the first crude efforts of painters; and he mentions Ardices and Telephanes as experts in the art of tracing outlines. The crude outlines obtained from shadows may be seen in the figures on Herulean vases of the first period, improved upon at a later period by substituting red-yellow figures upon a black ground, for mere outline in black. Eumarus is said first to have distinguished between male and female figures, and Cimon is reported to have improved upon these. Gradually the efforts of early teaching stimulated an advance, and, finally, Panänus, the brother of Phidias, is recorded as having painted the Battle of Marathon. One thing is certain—and the well-known Aldobrandic Wedding, probably dating from the period of Pompeius and Herculanum, proves this—the ancients were far advanced in their knowledge of the art of colouring and painting, and adopted methods of representation the modern school has not even dared to imitate.

But I must shorten my record. The purport of this essay is not that of an æsthetical disquisition: its object is purely scientific, and only collaterally I mention the progress of art. The extreme paucity of the Roman thought on all matters connected with physical science, as also that of the question of Light, impels me to notice their defect, and I quote these few sentences from Pliny in corroboration of what I have said. Lucretius is perhaps the only Roman author who has expressed philosophical ideas on Light;—not merely a simple narrative of the properties of Light, for he has rendered theoretical conceptions in his poem, the "*De Rerum Naturæ*," which contains also a resumé of the theories of the period. Shade and Light, and the mergence of colours one into the other, constitute the leading ideas developed by Titus Lucretius. Original conception, or even a guess at a new line of thought, there is

none: he was too much a Roman to accept new ground. The power of inception the Roman had not. The narrowing limits of a prescribed sphere of action of home life followed him, even when at the zenith of his power; and Goëthe alludes to this characteristic, attributing their complete want of originality to this fact. Be this as it may, no advance was made by the Roman. The name of Lucius Annæus Seneca needs, however, mentioning; not that he has told us anything new—he was too thoroughly the Roman to care for Nature, save for what she produced—but, at all events, he studied the phenomena of light, commented upon what he had read.

In casting a glance back, the long vista of ages vanishes into the distance of traditional periods, and closes in uncertainty, illumined only by the thoughts, the theories, the guesses of the Greek. All else is either utter darkness or mere repetition of what they had thought and taught. Succeeding the rule of the Roman Empire, came the dark ages—the long period of religious convulsions; the inroads of Huns and Goths. Europe seethed and heaved again with the turmoil of races at war with races. Centuries passed, the very records of former learning were lost, or lie buried in the cloisters of Italy, Spain, and France. Ten centuries elapsed; not a movement onward. These dark ages, as they are justly designated, had closed in upon the human race, in a long, never-ending night. But the soil for advancement was being prepared, the great mediatory act was progressing. Possibly some law may rule in the development of the human race, necessitating this retardation, that breadth, organic power, may be gained by the race in order to warrant the step onward. In the early stage of development, surrounding barbarism engulphs only too readily the few isolated oases of civilisation; the sand-drifts of the desert bury them in oblivion. Concealed in the

cloisters of Europe, lie hid the caskets with their peerless wealth, needing but the hand to open the lid and pour their contents into the lap of a people fit to receive them. This, too, occurred, and history records how it was accomplished.

The first ray of light that broke the adamantine walls of mental darkness came from the soul of the Arab. Who does not know the name of Alhazen,* the chemist, the astronomer? To him we are indebted for the discovery of the law of the difference of the angles of incidence and refraction, which, with wonderful acumen, he establishes, employing numberless experiments to verify his theory. His treatise on Optics is a lasting monument of the genius of the Arab; and it is with an unfeigned feeling of pleasure that we notice how he treated the delicate question of the subjective action of the eye itself. The language, as rendered by Risner, is quaint; but who would quarrel with language? Light, intellectual light, is what is needed after ages of darkness; and welcome it we do.

PART II.

FOLLOWING the name of Alhazen is that of ROGER BACON (1216), and we place his name cheerfully in front of this the second part of the first chapter. The learned monk, how grandly he stands alone amidst the barbarism of a priest-ridden age! Persecuted, denounced, even imprisoned by the General of the Franciscan Order, accused of witchcraft—yet there he stands, unable to cast off his intellectual gifts. He could not help it; he must and

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* Risner's Alhazen, lib. vii. Whewell's Inductive Sciences, tom. ii., p. 273.

would think. Though positively hated by his contemporaries for a failing over which he had no control, he actually thought! The dawn of the mental life of a race first awakens in the soul of the persecuted, hated, denounced thinkers—foremost of these at that period, was the heretical, learned, large-souled monk, Bacon. The barren, crude conception of things as a mere recognition through our senses did not satisfy him. He had to penetrate deeper into the essence of matter; and in treating of light he recognised a principle, an active, potent agency. Light, to him, was a primary power and virtue, which strives continually to impress the material with its presence. Light and shade, transparent and denser media, play an important part in Bacon's theories. When light passes through a darker medium, yellow and red-yellow are produced; but when shade limits light, to the effect of impeding the action of light, blue results.

The primary combining of light and shade is very simple; the complex varieties arise as nuànces are created and forms varied. The inventions of Bacon show a prescience bordering on the marvellous. The camera obscura he foretold with greatest precision; the solar microscope, the telescope, he depicts with such accuracy that one is led to imagine he had the objects before him to describe; the magic lantern he well knew. Indeed, the wonder of his mind surpasses belief. His writings are couched in quaint, odd language. Possibly the persecutions he had to encounter induced him to employ a phraseology that might serve to shield him, and which the priests at that period were only too ready to set in motion; possibly the mathematical turn of his mind furnished him with a symbolical language of his own making; another reason—he had to form a language to express new thoughts. Be this as it may, there he stands, torch in hand, on the highways of the

past, pushing his way onward unto new ground; a herald upon the paths over which we have travelled. He is accused of a weakness—of superstition, a predilection for the supernatural. Oh, if those restricted brains of ordinary men only knew that the supernatural is not the non-existing, but, on the contrary, the, to them, unseen, because nature has shaped them in too coarse a mould to understand the truth of the advent of new thought—these contracted-brained men would pause before denouncing the supernatural as aberrations of the mind. The narrow soul contents itself with the denial of the truth of the supernatural until, as Goëthe says, "the godly, the supermundane, displaces and destroys the generation unfit for its reception."

Once again, a pause in the history of advancing knowledge—a long, weary pause. From the thirteenth to the sixteenth century, scarcely a name appears worth recording. AVEMPAGES and AVERROES, the Arabs; AUGUSTINUS and THEMISTIUS, whose treatises on the subjective action of the eye alone merit comment; relieve the silence of centuries. VITELLO, the learned Pole of the thirteenth century, whose laws of the perspective are to this day admitted as a step in the advance made, was a contemporary of Bacon, and his extensive work on Optics attracted great attention at the time. He gives tables of calculations showing that the angles of refraction are not proportional to those of incidence. These tables Vitello asserts, are from his own observations; but their close approximation to those of Ptolemy, render this doubtful. It is interesting to follow the enthusiasm of Risner, who claims for his author, Alhazen, the merit of this discovery. Certainly Vitello's views are very sound. It was he who first noticed with great acumen that the refraction takes places towards the perpendicular, and that the quan-

tities of the refraction differ according to the magnitudes of the angles which the incidental rays make with the perpendicular surface.* I am not wishing to quarrel with Vitello, or pick holes in the sleeve of Alhazen; they are only too welcome guests in the period they lived in, and merely record what their respective biographers have said of them.

Three centuries had elapsed; not a movement of any note had been made; Europe intellectually slept,—so thoroughly and effectually had the rule of priests paralysed the development of the human mind. The scholastic school of that period confined itself to narrow disquisitions, to useless subtleties. The Bible, as a sacred writing, was studiously kept aloof from all criticism. A dead silence held the human race in bonds. Dante Alighieri (1255-1321), Francesco Petrarcha (1304-1374), Giovanni Boccacio, had lifted the shutter-lid—light had entered into their souls; but the great mass of mankind lay buried in a mantle of soul darkness. In France, the celebrated Nominalists, Jean Buridan and Peter d'Ailly (end of the fourteenth century), had rudely attacked the authorities of learning of the day; else, all slept. It was only with the resuscitation of the study of the Greek school that the campaign against priesthood and authority fairly commenced. Hermolaus Barbarus (Venice, 1454-1493) and Angelus Politianus (the former translated Aristotle, Themistius) first gave to Europe authentic translations of the works of the great Greek masters. But once that light had penetrated, and the dark vaults of narrow belief had opened their roof, then the purer rays of light re-entered to greet mankind, calling forth fresh power and growth.

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* Whewell's Inductive Sciences, tom. ii., p. 274.

I touch upon these all-absorbing topics, as I travel onward to the advance posts of learning. All but unavoidably, the history of the study of the laws of Light connects itself with the progress made. Physical science invariably advances in parallel lines with all the other branches of knowledge. So constant is this law, that arrest the development of religious ideas, and science will proportionably suffer. Check scientific, philosophic growth, and religion will wither and dry up in its very birth.

With the names of ANTONIUS THYLESIUS, SIMON PORTIUS, and the learned, persecuted JULES CASAR SCALIGER, I will usher in the advance made in the knowledge of the properties of Light.

Here the work of Ant. Thylesius, "*De Coloribus*," first merits our recognition. With what elegance he treats the subject; not that he tells us of aught that is new, but he has felt the pulse-throb of intellectual life, and speak out he must. The lines commencing with the words—

> "Parvula Sisyphio gens condemnata labori,
> Quas figura ipsa fecit, fertque refertque pilas,"

show the grace and elegance with which he handles the matter; an irresistible charm pervades his writings.

SIMON PORTIUS translated a small work on Colours, ascribed to Theophrast. In lieu of a preface, he writes a small treatise on Colours, full of historical notes, replete with suggestions, and given with the modesty of a true devotee at the shrine of Nature's truth. Goëthe alludes to his work with all the genial warmth of his nature: he calls it grand.

Julius Cäsar Scaliger (1484-1558), like his two predecessors, made no advance in the study of the laws of Light; he only criticises, compiles, compares. Inclining to the Aristotelian theories, he attacks those entertained

by the Platonists; but, I repeat, original inception of thought he had not. A philologist of unparalleled power, he fully grasped the difficulty of modern language, and well understood that to render what the Greek had said of colours, aided, as their language is, by inflexions and augments, the more imperative, substantive, fitted-for-command language of the Roman failed to do.

The biography of this remarkable man is indeed instructive. In his early days, a courtier; in later life, a soldier; in his maturer years, following the practice of medicine, he thought, and wrote, and laboured. Hated, persecuted, by the Jesuits of the day, who could not forgive his learning—it interfered with their monopoly—Scaliger, with all his faults, and the vanity of his race De Quincey alludes to, was nevertheless a great man—one of the brains that thought whilst others slept. He had acumen enough to recognise the immensity of the interest of the subject of Colours, their endless variety, and marvellous course of their origin, their creation.

It is strange that the alchymists should have aided so little in the very work they had undertaken. Superstition, it is true, underlay their learning; but they handled chemical substances; and what surer guide in the changes their manipulations were producing than that of Colour. Yet not a step in advance was made by them. Goëthe* quotes a passage from the pages of their mystic works. I have not space to translate and render in English the history of the fabulous King of Egypt, and his conversation with the hermit Morienus. Assos, or "Alum," is named by this mystic person as representing one of the primary elements. "Lato" (or red) and "Euthices" speak to Datin, and travelling through a range of names, all symbolical, a

* Farbenlehre, tom ii., p. 210.

result is arrived at we leave King Calid to understand—it transcends our comprehension.

With a feeling of relief we turn to THEOPHRASTUS PARACELSUS (1493), the learned Charlatan, as he is wont to be called. The quaint language he employs does not, however, deter us from following his thoughts. Sal, Sulphur, and Mercurius, are, according to him, the primary elements. Colour is produced by their combination. Sulphur is the active agent, giving birth to colour; or, in other language, Oxygen (Sulphur—Sal), a basic substance, and the visual act of the eye itself—a combinative mediative force that united the former—produced colour. He was, then, the first who suggested that chemical action effected and caused colours.

Four other elements he allows to exist, besides those named, but they are only the products of the primary elementary substances enumerated. There is, however, another idea he suggests—the theory of an *inward light*; an emanation from God, as the fundamental power of all things in this created world. This thought of Paracelsus proves great grasp of mind. Universal harmony, and the intro-existing of all in all, he boldly avows as an all-pervading law. The inward light is indeed the source of light: it is the exponent of a change, of a transition; and transition from one intro state to another, onward and differently elementarily-constituted existence, is invariably indexed by light.

BERNHARDINUS TELESIUS (1508-1588), HIERONYMUS CARDANUS (1501-1576), and JOHN BAPTIST PORTA, deserve notice.

Telesius more particularly attracts our attention; for he grasped the idea of the mysterious systole and diastole of Nature, that heave and throe in all her workings. Böhm and Schelling mention his book, the "*Colorum Genera-*

tione" (published at Naples, 1570)—a work replete with original thought. Colours are supposed to be created by heat and cold, conformably to his idea of expansion and contraction—the alternate action which underlies all phenomena as a fundamental principle of life.

Cardanus, though he offers no distinctive point to seize upon, was nevertheless original in his method of arranging colours. He fails, however, whenever he endeavours to grasp original ideas: these he could not master.

In 1560, Porta published his "*De Magia Naturali*," a work containing all that unremitting industry could garner and glean from others. His vivid imagination, quick perception, and ready aptitude of grouping phenomena, well fitted him for the task he had undertaken; and though his great work gives nought that is new (he compares the eye to the camera obscura), it renders a truthful and useful account of the sciences of the period in which he lived, and it is for that reason I make mention of his name.

I am now rapidly approaching the end of the sixteenth century. Many of those who acted their part in the seventeenth century had been born, and were occupied in preparing their way; but I find it more suitable to draw the line at this point, arbitrarily to a certain extent, yet sufficiently marked to justify the closing of the period. In quitting the sixteenth century, two men stand forth and bid us good speed on our road. These men are Francis Bacon (1561-1626), and Giordano Bruno (1550-1600), the learned, brain-creative man, whose soul broke bounds and sought a sphere of action of its own, burned at the stake in the market place in Rome—the teacher of Galileo's heresy, a friend of Sir P. Sydney, and open antagonist of the Aristotelian school. *(Lewes' Biographical History of Philosophy.)* Yes, burnt at the stake! A feeling as if the

hand sought the hilt, a convulsive twitch wrings through the frame as the account of the execution of the learned, genial, inventive philosopher Bruno is read. What a lesson to posterity! Prophetic of the coming change. Rude hands were soon to be ready to do battle with repressive, conservative Rome. The hour had come; the beacon lights of advance were lit by the hands of priests, as they in vain bound their victims to the stake. The martyrdom of Bruno, of Galileo—for his, too, was a martyrdom—heralded the morn of intellectual life. Come it would, and come it must, like the bore on the waters of the mighty river. Back, back it impels its way, urged onward by the floodtide of advance, of new intellectual life.

What Giordano Bruno taught is contained principally in dialogues in his works, entitled "*De la Causa*" and "*De L'infinito.*" Both are great monuments of thought. Well may Tennemann call him the most remarkable thinker of the day,* and Tasso write—

"La terra
Simile a sè gli abitator' produce."

It forms no part of my present object to comment upon his philosophy, but I cannot help speaking of him. He stands at the threshold of advance, torch in hand, beckoning us to step on to new ground: his name must be spoken. The precursor of Spinoza, Leibnitz, Descartes, Böhm, Schelling; a worthy successor of the Neo Platonists, whose school was tottering and yielding before the inroad of fresh thoughts.

Next stands FRANCIS BACON: the great positivist, the father of inductive philosophy, the lawyer, essayist, philosopher, statesman, awaits our notice. What a fund of learning in those short essays of Bacon! "The objective physical science," as Dugald Stuart terms his method of

* Tenneman's Geschichte der Philosophie, p. 335.

reasoning, how it turned men inside out, and compelled that rigid, thorough investigation of facts, which alone can lead to any permanent advance. The deductive, the guessing process (if I may use the word), is necessary, nay vitally essential; but it needs correcting, sobering down, moulding into shape; and this only a thorough acquaintance with "objective physical sciences" can give. Well did Bacon understand this; and though, strictly speaking, he had but few followers—(his method is too tedious to bear adoption)—the effect his writings had upon the period he lived in, and upon after ages, is read in every page of the classical literature of our language. Only incidentally Bacon touches upon the subject of light. Nevertheless, as the great inductive thinker, a place must be given him. He thought how to think; and though I might feel tempted to quarrel with his empiricisms, yet he effected such immense good in destroying the time-honoured and dust-covered authority of the past, that I greet him with true feeling of inward rejoicing.

From henceforth we approach a period of positivism, a noting down of facts that has paved the way for an advance of that dawn the present day is just becoming sensible of.

At this stage, it may be of use to recapitulate the advance gained; to recall what has been said on the properties of light. — The traditional teachings of the ancients contain only symbolical allusions to the phenomenon of light. Indeed the past is a sealed book; and not until we reach the period of the Greek, have we aught to record. The onward stride at this point of history was, however, great. Light is taught by the Greek to be an inward fire, a flame that reaches from object to object. The eye is recognised to contain visual subjective properties, and the coloured hues of objects are considered to be produced by shade and light intermingling. The ποροι of

Empedocles; the κρασις of Aristotle; the inward flame that emanates from the organ of vision taught by Plato; the act of opposites necessitated by the very act of seeing of Aristotle, are all thoughts in the right direction. The idea of the boiling of organic substances by light showed that the chemical properties of bodies in producing colours had been understood; and as we approach more towards modern periods, the idea of chemical action is again taken up by Paracelsus. Though the reflection and refraction of light had been studied by the ancients, and Ptolemy is supposed to have formed tables of refraction Vitello copied, the discovery of the mathematical properties of light—the true course of the phenomenon of the rainbow, which Aristotle vainly endeavoured to understand—were reserved for later days; and it was not until Alhazen, the Arab, and Roger Bacon, devoted their minds to the subject, that any true advance was made. The difference of the angles of incidence and refraction were at last measured, and new laws developed from this law, so simple, so near to the mind, that it is a wonder it should not have been sooner discovered.

The knowledge of the physical properties of light, more especially its radiant qualities, had thus far been grasped, as we close this century; the profounder laws that rule its existence, had likewise been seized with a firmer grip of mind. But it is time we should enter the portals of the seventeenth century, so important a period in the history of the knowledge of light.

CHAPTER II.

The Discoveries of the Seventeenth Century.

I HAVE now to enter upon a period in the history of the science I have been treating of, essentially that of progress. Be the theories promulgated worth what they may, men, at all events, had cast off authority, and learnt that original thought is alone the true friend to scientific research.

The war with Rome—the angry strife mankind had engaged in, resolved to pull down the obstructive barriers priestcraft and the equally sterile hierarchy of the authority of science had raised—was engrossing angry Europe. The Reformation had become a fact. Ulrich Zwingli (1518) of Zurich, Calvin (1531) of Geneva, Luther (1517) in Germany, had opened the campaign; and all the might of Charles the Fifth, the cruelty of Philip the Second, the horrors of the persecutions of Alva in the Netherlands, only added power to the great wave of progress that was flooding the shores of Europe. The Thirty Years' War (1618-1663), terminating with the Peace of Westphalia, had shattered the hierarchical powers enthroned upon the kingdoms of Europe. The advent of a great onward stride in science had been prepared on the battle-field; men could venture to think and utter their thoughts; and progress assuredly would show itself. Let us greet these men, as they meet us on our journey onward to the present day, as friends.

The scholastic school—the school of the modern Aristotelians—had become profitless; the human mind yearned

for something beyond. Experimental science, to which Bacon had given the impulse, had induced a closer, soberer investigation of the facts of nature; and though perhaps proceeding to the other extreme—the exclusive adoption of the experimental—this necessary corrective method, without which solid advance is rarely made, the very effort of research resulted in reinvigorating the human mind. Galileo and Volta in Italy had fairly grasped the task of understanding physical facts; though labouring in separate branches, each struggled vigorously for advance. Descartes, of whom I shall speak presently, had his mind fixed upon the properties of light; adapting Snellius' sines, had explained the coloured phenomenon of the rainbow. The refractive character of a ray of light, the sines of incidence and refraction, Snellius first suggested, had aided in comprehending the laws of light. The great Huyghens had conceived the *undulatory theory*, as opposed to the *emission theory* of Newton. Keppler's laws were becoming familiar text-words in the schools of Europe—everywhere a stir. The great cycle of human advance was nearing its summer solstice: onward, onward! was the cry; and the angry remonstrance of a frightened priesthood, the timid voice of half developed science, were spoken in vain; the big wheel was giving a turn, and the glaciers and snow-fields of a long winter were yielding their nature to the warmth of a coming spring.

On this threshold, how could I do better than mention the name of Keppler! JOHANN KEPPLER (*b.* 1571: *d.* 1630), of whom Goëthe says—"A pleasurable surprise lays hold of one in reading the biography of this thinker—to see what he became despite of adverse circumstances; it convinces that true genius will overcome all obstacles." Of him I must be allowed to say a few words: the genial, light-hearted, much tried, yet always creative soul, whose

life was one succession of extreme vicissitudes; not that he has told us much of colour—he only treats of this matter incidentally; but Keppler stands prominently on the pathway of human knowledge—so we must speak of him. *Colour*, he tells us, is a middle product of light and shade; their mutual presence produces iridescence. He noticed also subjective colours—all incidentally, but with the touch of a master-mind. The laws of refraction, as they more especially concerned astronomical problems, however, attracted his attention; and though he failed in his conclusions, he came, by aid of an infinite number of experiments, very near the truth, observing that about "one degree" was the difference of an angle of incidence and refraction. Strange that the simple rule stated by Whewell should have failed him, namely, that "the ratio of the series of the angles of incidence and refraction is constant for the same medium;" but so it happened.

The law of sines was, however, discovered by SNELLIUS, who observed that objects appeared to rise up when regarded through a glass cube,—and what Goëthe calls "Hebung." This also Isaac Vossius had noticed, and commented upon in his treatise, "*De Lucis Naturæ et Proprietate.*" He, too, alludes to the unpublished manuscripts of Snellius. Huyghens, in alluding to Descartes' plagiarism, says:—"*Quod itaque* (*Cartesius*) *habet, refractionum momenta non exigenda esse ad angulos sed ad lineas, et tuo Snellio acceptum ferre debuisset, cujus nomen more solito dissimulavit,*"—a hard hit at Descartes, to whom, despite of all his failings, the world is so much indebted. A nobleman by birth, possessing all the advantages the educational training of the day could bestow, RENE DESCARTES, with true genius, cast off the trammels of conventual thought, and sought his own path. It is, therefore, with unfeigned

pleasure, we bring to mind his theories of vortices, the odd similes he employs to express his ideas. Oft misunderstood, nay, even persecuted, the great Descartes still thought for himself. Let us study what he has taught.

Colour, Descartes ascribes to primary luminiferous globules, which rotate; and says yellow, and blue, and red, are produced by a greater or lesser speed of this rotation—a primary ether act, the undulation which Huyghens developed. The rainbow, however, is specially his own child. To him science is indebted for an advance step, and his praise can be uttered with unmixed feeling of pleasure.

The ray of light, says Descartes, that comes to us, after two refractions and one reflection, strikes the eye at an angle of about 41 degrees, and is denser in its nature than white light. It is true, Keppler had previously ascribed the rainbow colours to the presence of sunlight in the raindrop, and Antonio de Dominis, whose discoveries I will subsequently comment upon, had experimentalised on a glass globe; but Descartes first applied the theory of the sines of Snellius in explanation of these phenomena, paving the way to the right understanding of atmospheric refraction, diacaustics, and the applicability of these laws to optical instruments.* The rainbow led him to the investigation of the properties of light in a prism. He first used a prism of 30 to 40 degrees, and obtained a spectrum with wide interstices. His suggestiveness taught him that the limitation the ray of light underwent, caused the colours of the prism. He likewise observed that the spherical form had nothing to do with the production of colour. He then attempted to apply this law of limitation to explain the colours of the rainbow.

I can hardly do better than transcribe from the pages of

* Whewell's Hist. Ind. Science, tom. ii., p. 278.

Whewell* what he has to say of the discoveries of Descartes, though in doing so I may be guilty of repetition. "Descartes," says Whewell, "came far nearer the true philosophy of the iridal colours. He found that a similar series of colours was produced by refraction of light bounded by shade through a prism, and he rightly inferred that neither the curvature of the surface of the drops of water, nor the reflection, nor the repetition of refraction, were necessary to the generation of such colours. In further examining the course of the rays, he approaches very near to the true conception of the case; and we are led to believe that he might have anticipated Newton in his discovery of the unequal refrangibility of different colours, if it had been possible for him to reason any otherwise than in terms and notions of his preconceived hypothesis. The conclusion which he draws is, that 'the particles of the subtile matter which transmit the action of light endeavour to rotate with so great a force and impetus, that they cannot move in straight lines (hence refraction); and that those particles which endeavour to revolve much more strongly produce red colour; those that move only a little more strongly produce yellow.'" Undoubtedly we have here a clear perception of the properties of refraction.

I must also transcribe what Descartes says on the theory of the rainbow. A war had been raging as to whom the merit is due, and I render it with more detail for that reason. If Whewell is to be believed, De Dominis is not the first to have suggested the idea, and René Descartes merits the reward; but let us hear Descartes. He says†:—"I at first really doubted whether the iridal colours were produced in the same way as those in the prism; but, at last;

* Whewell's Ind. Science, tom. ii., pp. 280, 281. † Sec. ix., p. 19.

taking my pen and carefully computing the path of the beam of light as it falls on each part of a drop, I found that many more come at an angle of 41 degrees than either at a greater or a less angle, so that there is a bright bow terminated by a shade; and hence the colours are the same as those produced through a prism."

The only fault I have to find with the genial Cartesius is, as Goëthe justly remarks, his unwillingness to allow others the merit of having also thought and originated ideas. He suppressed the fact of his knowledge that De Dominis had experimentalised with the glass globe. But I will not be querulous: the outer rainbow theory is deservedly his.

The next friend who greets us is GALILEO GALILEI (1564 to 1642). Who does not know this name, familiar to every child!—the great astronomer and physicist, from whom ignorant priests extorted under torture the denial of his theory of the rotation of the earth—the martyr on the field of science—even the presence of a Medicis could not shield him. What a lesson these persecutions teach of the conservative repressiveness of superstition, of religion, of science, ready to hold mankind in perpetual bondage!

Galileo considered light as something material, something he could measure and grasp—approaching to the emission theory of later days; but light and colour had not that interest for his mind, too mathematical to deal with what was then considered more a subjective question.

ANTONIO DE DOMINIS, *de radiis visus et lucis*, &c., must now be mentioned. He owed his reputation to a moderately complete treatise on light and colour, but replete with suggestion and new thoughts. It was he who observed the darkening and colouring of rays in passing through denser media, and in the third chapter of his treatise he deals with coloured rays, as arising out of light

itself, by mere passage through a denser medium. Light and shade play an important part in his theory, and Whewell, in his censure of Goëthe, alluded to the adoption of his views, though more systematically treated and more fully developed by Goëthe. I may be allowed to quote (in translation) a few remarks of De Dominis, my reason being to have material before me to establish a parallelism between his opinions and those of Goëthe, which I shall have to show as I proceed. "That colours arise out of light," says De Dominis, "I do not doubt—nay, they are nought but light itself; for where pure light is present in a body such as starlight and in fire, its radiancy becomes impaired, the body appearing at once white. Add to light something dark, and in such a measure that light is not extinguished, then colours arise." Further on he says:—"Shade converts light into colour," and then illustrates his theories by numberless instances. The rainbow phenomenon he treated with great acumen, and attributes the coloured arch of the rainbow to the reflection from the bottom of each rain-drop, and illustrates this theory by drawings which show the reflection of the image of the sun from the bottom of the rain-drop. The difference of colour he attributes to the greater or less transit through the body of the glass or dense transparent body. Colours, with him, divide into those that belong to the surface of bodies, and those that are essentially created in light itself, which he designates as *emphatic* colours. I must further allude to his theory of the concave surface of the transparent globe reflecting light, it bears so materially on his theory.

Athanasius Kirscher (1601-1680), in his "*Ars Magna Lucis et Umbrae*," and Marcus Marco, are worthy of notice, though intrinsically they have added but little to our store of knowledge. Light and shade play an important part in their theories; and whilst possessing little

originality, like those of De La Chambre, they are of interest in as far as they prove the working of the mental organism of that period, and the widespread interest taken in the subject. Most of the later theories were elaborated by men whose names are but little known to the general public. Thus, of ISAAC VOSSIUS, M. Pankl says (1793) that he was beyond doubt the precursor of Isaac Newton in his emission theory; and on perusing his work—"*De Lucis Naturæ et Proprietate*"—the first principle ascribed to light, as the common receptacle of colours, which light primarily contains, though unseen in its pure white state, will be found to be most similar to the Newtonian theory. The synthetical, composite nature of light is clearly stated by Vossius, though the use of the expression sulphur, as symbolical of the burning principle of light, may mislead in the comprehension of his theory, unless, as we ought, we allow to it its true meaning (disguised in the quaint technical language of the day). The presence of sulphur, or a burning element, is the first cause of light, and light contains the colours. Goëthe takes the same view as regards Vossius' merit as Pankl. He says: —"Here we have, several years before Newton occupied himself with these subjects, his theory fully expounded. We are not contending in favour of Vossius, only we have to render historically what is before us."* The truth is, that the whole tendency of the age was to ascribe to the phenomenon of light an objective reality; and the master minds of that period, as in all ages past, only reflected the opinions, the ideas of the day.

ISAAC VOSSIUS (chap. 27) says of apparent colours: "The question is hard to answer, whence colours arise that are, so to speak, severed from the bodies themselves, desig-

* Farbenlehre, v. ii., pp. 296-305.

nated apparent colours, such as the colours of the rainbow, of the roseate of morn, or that pass through glass prisms and then disperse. From what I have said, it is evident that flames follow the colour of sulphur, and allow of all colours apart of black and white; for sulphur contains the two colours, but, properly speaking, they cannot be in the flame itself. It is true, pure flames appear white; but if they were perfectly white, they would appear transparent, and not mixed with another colour; and if transparent, would not give off light, or only very feebly. But that a flame should be black is against all reason." After commenting on the properties of sulphur, he says farther: "For though no colours appear in the pure flame, they are, nevertheless, contained in the flame; for as a more brilliant light kills a less brilliant light, a pure light prevents the seeing of the dimmed light. But that each flame, each light carries colours within it, may be shown by passing through a glass lens a ray of light into a darkened chamber; colours will form upon the opposite wall, whilst on the cross joints of the rays and the points close to the lens no colours, but only white light will appear." After reasoning on these phenomena, he concludes as follows: "What is the true permanent fixed colour? equally, what are apparent colours that vanish and are unsteady? True colour is a degree, a measure of burning of a body: the apparent colour is the image of a true colour seen away from its source and origin." Very conclusive this reasoning; and I have translated the passages as useful in establishing Vossius' claim of having originated the emission theory.

Franciscus Maria Grimaldi, the Jesuit, the third, according to Goëthe, who had devoted his time to the study of the laws of colours,—a student of the University of Bologna, a profound mathematician, exquisitely skilled in experimentation, sound and clear in his views—he

attributed to light a fluidity, an emanation, and added to the known laws of direct action, refraction, deflection, that of the "*inflection of light.*" To the hypothetical fluid, he ascribes the qualities of liquids, "*undulatio,*" "*agitatio,*" "*volutatio;*" and ascribes colours, and the changes both in the direction and nature of light, to "*dissipatio,*" "*diffractio,*" "*discissio,*" "*separatio,*" and "*glomeratio.*" His ingenuity suggested to him a minute porosity in substances, in and through which this light fluid entered, and changed as it passed in and out of the minute interstices of matter. He, too, asserted that colours are modified light, and recognisable in a special manner by the senses.

I have also to mention ROBERT BOYLE, the timid learned man. How nice his modest way of putting forward the theories of others, and then, all but apologetically, he asks whether corpuscular mechanical explanation might not clear the ground of the difficulties others had in vain sought to remove; and, with true intuition, foresees the objection to the emission theory of Newton.*

But I must pause. I never intended to have given in chronological order the theories of those who had laboured on this special field of science; but it is so tempting to follow the men, century after century, and extract from their works their opinions, that I have been induced to go beyond my prescribed limits.

The name of CHRISTIAN HUYGHENS (1629) brings me to the consideration of the undulatory theory; and, with this doctrine, the names of Hooke, Young, Fresnel, Biot, Ampère, are so closely connected, that I cannot but group them together, though in point of time they stand wide apart. And

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* Robert Boyle's work is entitled—"*Experimenta et considerationes de coloribus, seu initium experimentalis de coloribus, a Roberti Boyle. Londini* 1665."

foremost, then, HUYGHENS: the wonderfully erudite, suggestive mind of this great mathematician and physicist (it was he who discovered the ring of Saturn) attracts us. Dissatisfied with the explanation of others, and arrested by the many unaccountable phenomena of light, and more especially unable to explain the phenomenon of polarisation of light, which he appears to have noticed several years before the publication of his undulatory theory (*Tr. Opt., p.* 252), he* conceived light to be a *luminiferous ether wave*, which expands itself spherically, not unlike that of the wave of sound. The wave of undulation diffuses itself in all directions; and hence the inference that light will not be diffused beyond the rectilinear space, when it passes through an aperture.† He noticed that the waves of light, though they diffuse themselves outside the rectilinear space, only concur in front of the refracting medium.

By the undulatory theory, Huyghens explained the laws of refraction and reflection; so, also, the laws of polarisation. In the crystal of the Iceland spar, he conceives that, besides the spherical wave, a second one—a spheroidal one in form—co-existed, and that the axis of this was symmetrically placed in reference to the rhombohedron. Aided by his mathematical talents, he was enabled to discover that the spheroidal undulations, in their refraction, coincided with the refraction in the Iceland spar.

Since the first promulgation of this theory—now the pillar of support of optical phenomena—great advance has been made towards perfecting its conception. HOOKE,‡ the Secretary of the Royal Society, so also FATHER PARDIES, and NICOLAUS MALEBRANCHE, the expounder of the theories of

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* Whewell's Hist. Ind. Science, vol. ii., p. 314.

† Huyghens' Traité de la Lumiere.

‡ Micrographia Hooke, p. 56; and chap. viii., p. 57.

PATER MALEBRANCHE, had each in their own way conceived that a vibration, either objective (Hooke), or in part resulting from a subjugative vibration (Malebranche), caused the phenomenon colour. "A quick, short, vibrating motion, propagated in a homogeneous medium, is light—each pulse generating a sphere," are the words used by Hooke. The coloured fringes noticed by Grimaldi, and the colours of thin plates, he justly concluded, could only be explained by the presence of a wave of light. Of importance is the discovery of "Interferences." This, Hooke says, is occasioned by two refractions and one reflection, a fainter ray following the reflected wave. Each colour has a different pulse; and the layers of the thin plates of glass determine the length of the wave. The idea of a vibration, if properly considered, is not so foreign to the mind; and though less clearly expressed by Descartes in his theory of luminous globules rotating in given proportions, a similar idea is there presented as are in all the leading thoughts of mankind of the period, in the minds of various thinkers—differently, oft times obscurely expressed, but nevertheless existing, and seeking outlet through the utterance of the mental organism of brains fit for their reception. Newton at first appears to have favoured the undulatory theory;* but, subsequently, the emission doctrine, first promulgated by Isaac Vossius—whom M. Pankl, as already observed, calls the precursor of Newton—was finally accepted by

ISAAC NEWTON (1642-1727).† With what consistency and boldness he carries his favourite idea through all the obstacles of inexplicable phenomena. The colours of thin plates, for instance, he explains "by fits of easy transmission and reflection," and with marvellous fertility of mind forces his way through a whole thicket of difficulties. It is,

* Opticks, p. 322. † Prop. 94; Opticks, p. 322.

however, of interest to notice that, despite this obstinacy, the undulatory theory still had a hold upon him; and he asks, "Do not these vibrations overtake the rays of light?"* as if in half admission of the truth of the doctrine he was contending against.

The theory of Sir Isaac Newton may be stated as follows:—Light is a substance emitted in rays from the luminous centre, and becomes divisible by refraction: for instance, a prism will show violet, indigo, blue, green, yellow, orange, red. At its point of emission light is pure white, and may be decomposed, analysed, separated into its elementary parts by two processes—namely, *refraction* and *absorption*.

The first process is by the well-known experiment of passing a beam of light through a prism. The celebrated "*Experimentum Crucis*" (the 6th Experiment)—and with which I shall deal farther on—details the mode of proceeding; suffice, then, if I mention the result Newton arrived at, which was, that the light of each separate colour possessed the same index of refraction. He called such light "*homogeneous light*," in contradistinction to "*white light*," and which he designated *heterogeneous*, or compound. The prism colours are primary colours, and the mixture of these again produces secondary colours; the recombination of all these colours reproduce white light. The second part of his theory is that of the *absorption* of light, which, if reflected or refracted, is always less than the quantity originally impinging upon a body.

Newton postulated from these data, "That to the same degree of refrangibility ever belongs the same colour,

* Edin. Review, v. i., p. 450; Whewell's Hist. Ind. Science, v. ii., p. 348.

and to the same colour ever belongs the same degree of refrangibility." That this is not the case, I need hardly aver; the fact is too well known to need refutation. Colours do act absorbingly; and the experiments given by Brewster, with a piece of blue glass, are conclusive. The latter assumes red, yellow, and blue as the primary colours existing at every point of the solar spectrum. To me this view of Brewster is of intense interest, concurring as I do with Dr. Jencken in the polaric nature of light. White light may be reproduced at any point of the spectrum, and once produced, will sustain its intensity through many refractions and reflections.

It is instructive to follow the dispute that raged between the emission and the undulatory theorists. EULER, with considerable acumen, remarked that an emission theory compelled an admission of a supply of material to the incandescent body; and whence was this consumption to be supplied? "The weight and authority of Newton," says Whewell, "however, prevailed," and for full a century the emission doctrine—which in truth is far more easy to understand than that of an undulation of a lumniferous ether—became the accepted opinion of this land. Huyghens was all but forgotten, when

Dr. THOMAS YOUNG (*b.* 1773) first published his memoirs on undulations. The wiseacres of Edinburgh could hardly contain their wrath: "fanciful," "absurd," are the terms used; "we are much disappointed to find so acute and ingenious an experimentalist should have adopted the wild optical theory of vibrations," says one of the reviewers of the day. I quote this passage to show how thoroughly wedded to the emission theory was the scientific mind of that period, so that any opinion differing from the accepted view, was treated as heterodox, and assailed accordingly.

But as Huyghens had foreseen, certain phenomena of

light—for instance, polarisation, interferences, and double refraction—could not otherwise be satisfactorily explained. This Dr. Young well understood; and it may be of use to state briefly the phenomena that can only be understood by the aid of the undulatory theory; these are:—

1. Periodical colours, fringed shadows (first noticed by Grimaldi).
2. Double refraction (which Brewster so ably explains in his work on Optics).
3. Polarisation and dipolarisation, and other forms of polarisation.

The emission theory wholly failed to satisfy the ingenious, thoughtful Young; thus then he gave his mind to the undulation theory, and in 1799 published a paper on "*Sound and Light.*" In a subsequent paper (1801) he says: "The *striated surfaces* confirmed my mind in the truth of Huyghens' proposition." It is true, Young did not originate this theory, but he systematised the materials collected by Grimaldi, Maraldi, Malebranche, and others, and gave the results to the world in a scientific, compendious form. One mistake, however, he made,* in supposing that light reflected in a rarer medium is retarded by half an undulation—an error his successors rectified.

It was not until 1815 that the labours of Dr. Young began to attract attention, when Fresnel, in his "Memoir on Diffraction," delivered at the Institute, first called attention to the importance of seeking an explanation of this phenomenon by "an undulatory wave."† The principle of interference and theory of undulation was, at the

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* Brewster's Optics, p. 210—Interferences. Whewell's Hist. Ind. Science, p. 224.

† Brewster's Optics, p. 126.

request of the Institute, examined by Arago, who fully confirmed the view taken, adding in his report, that "the laws propounded by Fresnel were destined to make an epoch in the history of science."

I have already alluded to Newton's explanation of the colours of thin plates, by "fits of easy transmission and reflection" — an arbitrary, untenable hypothesis, which Young and others attacked. Fresnel explains this phenomenon by the undulatory theory: "it is," he says, "the crossing, the meeting of the rays, which produce coloured fringes"—consequently, as Whewell remarks, "a mere translation of the phenomena, and wholly inexplicable on the emission theory."

It is necessary to remind the reader that, by the emission theory, a permanency, an undiverging constancy, is ascribed to the ray of light; and in all the twists and turns produced by thin plates, Iceland spar, double refraction, &c., &c., the ray is supposed to remain true to its nature. This appealed so forcibly to the minds of Young, Fresnel, Arago, that, with a clear intuition of the truth, they rejected the more material theory of an emitted ray of light, and accepted Huyghens' theory. Fresnel, once having accepted this theory, sought for confirmation, and his table of the "correspondences of theory and observation" is a masterpiece of close mathematical reasoning; and though the integrals are most difficult, he accomplished the task of adapting them to the experiments he had undertaken with marvellous skill.

Satisfied with the truth of this law, Fresnel continued his researches. A host of hitherto unaccounted-for phenomena lay in wait for him. It is of interest to notice how hesitative Fresnel and Arago were in applying the undulatory theory to all the phenomena of light. For instance: the law "that two rays of polarised light at right angles

give the same quantity of light," was first laid down by Young. Arago and Fresnel confessed that they had conceived this thought, but were afraid to commit themselves to its publication, aware how contrary this law was to the ordinarily accepted notion of the vibration of fluids.

The great difficulty the undulatory theory had to contend with, was how these elastic fluids could be called into play at one and the same time, and the further difficulty of the different polarisations of the waves themselves. Here the theory of transverse vibrations* came to their aid: for this occurs—Suppose transverse vibrations, passing through a uniform medium, to enter a non-uniform medium, with different elasticity, what will be the course of the wave of undulation? This question Fresnel answered in his celebrated memoir, November, 1821. He conceived that the surface of the undulatory wave was complex, resolving itself, as in uniaxal crystals, into a sphere or spheroid; but which forms ordinarily are of a continuous double envelope of the central point to which it belongs, intersecting itself and returning into itself. In biaxal crystals, the rays are determined in their direction by the surface curve; in uniaxal, by the sphere and spheroid; and the result is, "that in biaxal crystals *both* rays suffer *extraordinary* refraction, according to the determining laws." Applying this law to polarisations, Fresnel supposed that in every case the plane of polarisation was perpendicular to the transverse vibrations.

I have not space to investigate more in detail the laws of polarisation (of which, however, I furnish explanatory notes), and refer to Fresnel, Brewster, and Malus, for fuller explanation.

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* Whewell's Hist. Ind. Science, vol. ii., p. 334. Brewster's Optics, pp. 146, 147, 150.

The negative and positive character of light may be observed in almost every experiment with crystals, and the double refracting character of glass unequally cooled. Indeed, of all bodies, including salts and crystals, not having the primitive forms of the regular octohedron, the rhomboidal dodecahedron or cube, as also the bodies of animals, hair, skin, and other animal forms, like those of plants—in fact, all substances having unequal densities, *doubly refract light;* and in the circular double refraction, Fresnel discovered that the refraction is positive or right-handed, and negative or left-handed. The image is seen diverging off at an angle, varying in different substances, but divergent —that is, the ray of light itself severs; and this could only be the case by the ray being in its very character dual—negative and positive—that is, polaric in its formation. The planes along which refracted rays pass vary, and may, as is the case in the analcime, be in almost any position.

Polarisation is an absolute act of severance of the ray of light. Each ray carries in itself the tendency to separate polarically—the plane of the crystal only aids this tendency. Similarly the prism assists in producing colours, by resisting the direction of the ray of light, only momentarily; it arrests, nevertheless, its progress, and at the point of resistance light shows its polaric character, colour is produced, of which fact the prism furnishes an illustration. Polarisation, according to Malus, has its maximum angle at 56° 45′—the power decreasing if polarised at 56° — but the angle varying with different bodies; hence Malus justly concluded that this singular property neither follows the order of the refractive powers, nor that of dispersive powers, but that it is a property of bodies independent of other action which they exercise over light.

After a series of experiments, Brewster, in explaining it, gives the simple law of this phenomenon. He says:—"The index of refraction is the tangent of the angle of polarisation;" and that "the maximum polarising angle for all substances whatever, is the complement of the angle of refraction;" and, finally, that the reflection upon a second surface, the index of refraction, is "the cotangent of angle of polarisation."

The rays from the spectrum are polarised at different angles. This enables us to explain the existence of unpolarised light at the maximum polarising angle. Brewster has given us his explanation, and has shown, with characteristic acumen, that, finally, each of the two planes of its component polarised beams is turned round into a state of parallelism, so as to be a beam with only one plane of polarisation. This is a mode essentially different from polarisation by double refraction.

The laws of polarisation expand as we continue our research, and I regret I have not space to give in detail the beautiful experiments of the colours of crystalised plates in polarised light.

The polarisation by ordinary spectrum, though less attractive, from its simplicity, discloses again the dual polaric character of light—each plate of glass, by the mere act of arrest, increasing the divergence of the ray; and light, after passing through, say eight plates, becomes completely polarised.

I must name another discovery—one for which we are indebted to Brewster—namely, that of producing coloured rings in crystals with one axis. In this experiment, the concentric rings of different colours are intersected by a black cross—the black cross vanishing, and the colours becoming complemental, as the plate is turned; the intervals being marked, if expressed in degrees of a circle, by

45°, 135°, 225°, and 315°; the complemental numbers being positive to these, that is, producing normal colours.

Brewster discovered minerals possessing two axes of double refraction, as well as of polarisation. I can only allude to these properties of light, and must refer the student to treatises on these subjects for further information. But the dual character of light is what I desire to saliently place before the reader. This character it maintains in every phase of its varied and complex course—not as an exception, but in obedience to the very law of its creation, at the vortex point, at the light point itself.

The laws of interference of polarised light (which Brewster has given in his chapter on interferences), and the laws of circular and eliptical polarisation, all confirm this character of light.

In consequence of Dr. Young assuming that ordinary light and extraordinary light travel at different velocities through, for instance, calcareous spars—which ought to produce interference, but which they do not—his explanation was neglected until the laws of the interference of polarised light were established by MM. Arago and Fresnel, who showed that the rings in the beautiful experiment of coloured rays in inflexion of light depended on the incident pencil being polarised, and its subsequent analysis by a reflecting plate. The experiments made by M. Fresnel in proving the inflexion of light, he repeated, and the coloured rings received upon a screen; but in this instance, bundles of mica were placed (10 to 15 plates) before the slits in the first aperture of a thin copper plate, and behind the focus of the lens. These mica plates were so formed as to revolve; he then discovered, that when the bundles were so placed as to polarise the rays in parallel planes, the fringes were formed by the slits, exactly as when the bundles were removed; but

when the rays polarised at 90°, or at right angles, they wholly disappeared.

The fifth rule, as laid down by M. Fresnel is as follows: —"In the phenomena of interference produced by rays that have suffered double refraction, a difference of half an undulation must be allowed, as one of the pencils is *retarded* by that quantity from some unknown cause." *(Brewster's Optics: Chapters on Polarisation.)*

Circular polarisation offers another illustration of the dual property of light. Polarised light comports itself at its egress from the crystal, as if its plane of polarisation revolved in the direction of a spiral within the crystal; in some specimens from right to left, and in others left to right. Fluids, though less marked in their effect, possess this remarkable property discovered by M. Biot and Dr. Seebeck. Turpentine, for instance, gives a distinct rotation from *right to left*, others again *left to right*.

The polarisation by metals was first established by Sir David Brewster, and to which he has given the term "*elliptical polarisation*," as uniting the two classes of the phenomena of *circular* and *rectilinear*. Gold, silver, and other metals, divide the polarised rays into their complementary colours, by successive reflections: and, curious enough, the number of reflections vary in different metals. For instance, Sir David Brewster found that "common light is polarised by *steel* after eight reflections, and in *silver* not till after thirty-six reflections." The discovery of the transparency of their metal films, each varying the colour of ordinary light, which I mention here, proves the active penetrative power of light in metals themselves; and the intense centrality of silver further establishes the fact, that polarisation is only produced whenever the ray itself, by contact with the surface impinged upon, loosens, so to speak, the combination of the primary, dual, polaric

element in light itself. Silver is too concentrated to act at first, hence the rays need thirty-six reflections; in other substances, less and less; and in all coloured and non-reflective surfaces, the transitions take place so rapidly, that we have no means at present of measuring them.

Heat and cold, dilatation, compression, sudden and unequal cooling, produce the same results of polarisation. Indeed, any strain, even the passing of an electrical current through a rod or cylinder of glass, and which Professor Tyndall has shown, produces double refraction, polarisation. For instance, cylinders of glass with one positive axis of double refraction, heated and submitted to polarised light, will exhibit coloured rings until the heat reaches the axis of the cylinder, when they will gradually become less defined, and finally vanish. A cylinder of glass with a negative axis of double refraction, will do the same; but if the rings be crossed, they destroy—that is, neutralise—each other. Cubes of glass, oval plates of glass, and rectangular plates, produce similar phenomena; and the beautiful phenomena of tessellated crystals furnish a means of discovering structures which the microscope could not possibly detect. The *bipyramidal sulphate of potash*, the primitive form of which is a *bipyramidal dodecahedron*, furnishes an elegant instance of the property of polarised light. The crystal is so firmly bound together that the microscope utterly fails to show the joints of the surfaces. By the aid of polarised light, Sir David Brewster ascertained it to be composed of several crystals—the crystal itself having two axes.

The *dichroism* observed by Dr. Wollaston, depends upon the absorption of polarised light, and the property of *muriate of palladium*, of giving *red* along the axis, and *green* in a transverse direction—a property Herschel found in other substances, such as *sub-oxysulphate of iron*, illus-

trates the wonderful property of light in its dual character. Brewster's explanation that the double refraction results by compression of two atoms brought together by attraction, is very well put. He says—"For each particle will have an axis of double refraction in the direction of the line joining their centres, as if they had been compressed by an external force." *(Phil. Transactions,* 1829.*)*

I have, however, said enough on polarisation. The object I have in view is to show that light, in its character, is polaric, and that it continues its primary dualism throughout; and the phenomena of polarisation of light prove that arrest, check of any kind—it may be at the surface joint of crystals, or on the reflecting surface, repeated, as is the case from silver mirrors, thirty-six times, or it may be by the presence of heat—effect a change in the condition of light, like that produced by the prism, and to which law Brewster has called attention.

Suffice it that, once a law established, its application to a series of phenomena soon followed. The mechanism was, so to speak, complete, and Fresnel well knew how to set it in motion. But here the difficulty did not terminate: polarisation by reflection had to be explained; and Brewster relates how Malus, while looking through a prism at the light of the setting sun reflected from a pane of glass of the Palace of Luxembourg, discovered that, at an angle of 56° from glass, or at 52° 45′ from the surface of water, a beam of light possessed the same property as a ray formed by a rhomb of calcareous spar—that is, became polarised. This property of light Malus discovered to be a property of bodies independent of the other modes of action which they exercise over light. Fresnel fully grasped the difficulty, and resolved it by "laws of collision of elastic bodies;" and, following up his theories, he concluded that the reflection of light through a rhomb of glass

of a certain form (called Fresnel's rhomb) would produce a polarisation of a kind differing from that his theory had previously dealt with—namely, circular polarisation,* and to which Arago (1811), M. Biot, and Herschel had given their attention. But polarisation—circular polarisation—is not confined to crystals: for instance, oil of turpentine, essential oil of laurel, and turpentine, turn the rays right to left; whilst concentrated syrup and essential oil of lemons, left to right. Metals, too, produce elliptical polarisation, and Brewster furnishes tables of substances and the inclination of restored rays. Heat and cold, also compression, produce this strange phenomenon, and one which Fresnel and his followers could only explain by the law of undulation of a fluid—the emission theory, with its "fits of easy transmission," utterly failing to grasp the facts it was required to explain.

The next feature of the inquiry is that of *Dipolarisation*, on which subject Young published his memoir in the *Quarterly Review*, 1814. A word, however, in advance of this phenomenon, which latter gives, as it were, a key to the objection to the emission theory of Newton, showing by simple demonstration its utter inapplicability. *Di*polarisation is not a *de*polarisation, but, in fact, the combination of a new polarising agency. This phenomenon Arago communicated to the Institute of France, August, 1811. In his memoir he describes the colours seen by passing polarised light through mica and analysing it with a prism, and which is the dipolarisation Fresnel endeavoured to explain. These phenomena M. Fresnel accounted for, by supposing a polarisation in the first instance; then showing the effect of the crystal dipolarising; also the action of the analysing plate, from which colours result by

* Brewster's Optics, pp. 164-216.

given portions of the rays in the crystal interfering with one another. These phenomena are so complex that, for further detail, reference ought to be made to Fresnel and others on the subject.*

I have, for that reason, given an account of the undulatory theory, accompanied by extracts from the works of Young, Fresnel, Biot, Malus, and Brewster, and have but little else to say, unless I take up controversial ground, which, if I ever do, I must reserve for some future occasion. Faraday's great discovery—that magnetic polarity and optical polarity are directly connected—now requires notice; it forms an important feature in the history of these great discoveries. I will follow Faraday in his experiments; by doing so I may aid in the comprehension of the subject. "A ray of light," Faraday tells us, "polarised and transmitted through certain transparent substances, placed in the line of force or action, connecting the opposite poles of an electric magnet, is so affected by this power, that it becomes visible or insensible according as the current is flowing or not at the moment—this influence being more complete as the ray of light is more exactly parallel to it. The changes thus produced are instantaneous, certain, and capable of being repeated as rapidly as the current can be suspended or renewed."

Here we have, then, another interfering element—light magnetised—the image of the flame lamp rendered visible during the continuance of the action of the magnetic stream, and becoming again invisible the instant it is interrupted.† "In a beam of ordinary light the particles of luminiferous ether vibrate in all directions perpendicular to the line of progression," says Professor Tyndall. "By the

* Ann. Chim., tom. x.

† Faraday as a Discoverer: Professor Tyndall, January, 1868.

act of polarisation, as performed by Faraday, all oscillations but those parallel to a certain plane are eliminated. In the experiment of Faraday, the magnetisation of light and the illumination of the magnetic lines of force becomes, when expressed in the language of the modern theory, '*the rotation of the plane of polarisation.*'" Upwards of 150 substances were submitted to the test, and all showed the power of effecting polarised rays. What is so remarkable in these experiments is the change of a transmitted beam from a state of darkness to brilliancy, on the magnet being excited; and to follow Faraday's own words: "We may," he says, "justly affirm, that a ray of light is electrified, and the electric forces illumined."

Any strain or sudden change in the condition of a medium, by heat or cold, will alter the molecular state, and the symmetry of substance interfered with: the ether wave is supposed to be impeded, and the glass becomes doubly refractive; hence gases failed to give Faraday the sought-for result. "The luminiferous ether surrounds, and is influenced by the ultimate particles of matter:" the symmetry of one involves that of the other;* and Professor Tyndall gives the elegant experiment of a glass rod doubly refracting, when caused to sound a fundamental note, but which a column of air, vibrating and sounding the same note, will not do.

At the present day, with the authority of M. Arago, M. Fresnel, Sir David Brewster, Airy, and a host of illustrious names to countenance the undulatory theory, it may be of some use to cast a look back to the days of its early struggle. The lesson is instructive: it touches the resistance in the human mind before assimilating a new truth.

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* Proceedings R. I. of G. B., January, 1868.

Lord Brougham, in the *Edinburgh Review*—(it is true, then only twenty-four years of age)—speaks in language of unmeasured censure of Young's theory of light and colour. I do not quarrel with him for this; only, may it not be an instance to profit by, teaching us the danger of rejecting new ideas, simply because they clash with current opinions? Even Brewster disclaimed; and so strong was his aversion to the undulatory theory, that thirty years later he still showed signs of his former dissent.

Thus much for an outline, a history of the principles of this world-renowned theory, which is so exquisitely beautiful, adaptable, to explain optical phenomena. The question has, however, been raised by Euler, whether the universality of the law really is sustainable; and Grove likewise suggests that possibly another law may apply to light. Light is not solely a *radiant, visible* element:* light has other properties which cannot be overlooked; it oxydises, colours, and bleaches. Light becomes absorbed; light changes into heat, and heat into electricity; in fact, light, in its radiant, visible character, only shows one of its many phases. Light holds many forces within its beam. Need I allude to photography; the change of solar power; the correlates of light, which accompany, precede, and follow light; surely they warrant attention. The danger of a theory like that of an undulatory, luminiferous ether, is, that it is so readily made to fit to a mathematical formula, which the very acuteness of the minds of Young, Fresnel, Biot, and Malus endangered, rendering the universal applicability of the theory, by the very readiness with which the wave motion, on the assumption of the laws of an elastic fluid, was made to explain the different phenomena as they presented themselves, a serious ques-

* Whewell, vol. ii., p. 344.

tion of doubt. But there are other objections to this theory, which Euler foreshadowed, and which Grove* puts in clear, unmistakable language. Grove ascribes light to a "vibration or motion of the molecules of matter themselves, rather than to a specific ether pervading it, just as sound is propagated by the vibrations of wood, or as waves are by water." The conduction and non-conduction of electricity, the phenomena presented by magnetism and heat, the phenomena of fluorescence, of phosphorescence by insulation, tend to show that matter is molecularly affected, and that fluids and undulations of ether, which is only a mode of motion, co-exist. Why, again, are porous bodies not transparent; for it is evident the ether wave hypothesis assumes that the space between the final molecules of matter allows of the passage of the wave of motion? *(Grove.)* This final space must in reality be very great; and transparency ought to result from the less or greater distance of the molecules, if this theory of undulations be correct.†

But I will quote from Grove. He tells us so clearly what he has to say, that I give his own words. After commenting upon Leonard Euler's view, and with which he agrees, he says (p. 164):—"Although this theory has been considered defective by philosophers of high repute, I cannot see the force of the argument by which it has been assailed, and therefore, though with diffidence, I still adhere to it. The fact itself of the correlation of the different modes of force, is, to my mind, a very cogent argument in favour of their being affections of the same matter; and electricity, magnetism, and heat, might be viewed as produced by undulations of the same ether as that by means of which light is supposed to be produced,

* Grove's Correlation and Continuity, pp. 163, 164. † *Ibid*, p. 164.

yet this hypothesis offers greater difficulties with regard to the other affections than with regard to light." Farther on he says:—"If it be admitted that one of the so-called imponderables is a mode of motion, then the fact of its being able to produce the others, and be produced by them, renders it highly difficult to conceive some as molecular motions, and others as fluids, or undulations of ether."

There are, however, still graver objections than even these, and which rest upon the difficulty the assumption of an ether presents. A constant, invariable, ever-passive medium, existing only for the purpose of the reception of undulatory impulses, capable of being set in motion, and continuing so, by an impulse from without, is an assumption without any proof. A permanency is thus given to an all-pervading element, an unchangeability, which I cannot concede to any form or element in nature, where all is change, transmutation, in never-ending progress and onward development.

I must, however, conclude this part of my treatise. It would be impossible, without occupying more space than I can allow myself, to enter more fully into the question of the merits of the undulatory theory. Suffice it, if I repeat, that seducively elegant as the undulatory theory undoubtedly is, and singularly applicable to explain "Interferences," external coloured fringes, and furthermore adaptable, with wonderful facility, to explain many of the phenomena of light—the theory, inasmuch as it necessitates an ether element, as already said, passive in its nature, acted upon a dead material, passively accepting impulses from without, and yet able to communicate, is not sound: it assumes that of which we have no proof, and which is contrary to the known laws of nature. The correlates of light, as Grove designates "heat, electricity," magnetism, and the gravitation of cosmic bodies, the motion in space, stand

begging at the door of this theory, wholly unexplained, save by long and short waves, or waves vibrating at angles different to the axial plane of direction. Molecular action, what *becomes* of it? Or, are there many ethers (asks Grove) which co-exist and pervade space? If not, we are driven back to allow to one group of dynamical forces molecular action, to others, wave undulations — a perplexity it is hard to get rid of, a difficulty it is impossible to clear away.

CHAPTER III.

The Emission Theory.

I MUST now deal with the corpuscular doctrine. This theory assumes that a specific fluid, proceeding from the luminous bodies themselves, produces light, the particles impinging upon the retina. Light travels, according to this theory, 192,500 miles in a second,* is material in its nature; and ISAAC VOSSIUS,† says, in his work entitled "*De Lucis Naturæ et Proprietate*," that light contains all the primary colours, and white light is the origin of colour, not colour itself. Light being a fluid, emanating from the luminous centre, is supposed to be synthetical, composite in its nature, holding within itself the elements of colour and re-combination of coloured rays: yellow and blue reproducing white light. It was Vossius who, objecting to the theory of the ancients, ascribed to light a simple, pure nature, and first conceived its complex form as a bundle of coloured rays. In 1672,‡ NEWTON published his theory, that light consists of rays of different colours and different refrangibility. The image or *spectrum*, which we will hereafter more closely examine, appears on passing a ray of light through a small round hole, and making it travel through a prism, not round, but oblong, on the opposite wall; and from this he inferred

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* Romers.

† Isaac Vossius—1618, d. 1689 (Amst. 1662). Phil. Transactions, vol. ii., p. 3,075.

‡ Mat. Pankl, comp. J. P. 1793.

that the colours were differently refracted; and he further attempted to show that, when re-combined, they produced white light.* He subsequently confirmed this theory by making each colour refract separately, and thence he inferred that each ray of light contains the primary colours, divisible by refraction, but unchangeable in their nature, each ray, as already mentioned, possessing a different degree of refrangibility, and he accordingly dealt with light as material substance, impinging upon and penetrating matter; though in promulgating this idea, Newton hesitated in attributing an absolute materiality to light. I will now proceed to further explain his ideas, by dwelling upon the salient features of the emission theory, and dealing with them separately. The invariability of the spectrum image is the weak point of the Newtonian theory: the coloured rays, into which white light is supposed to divide after refraction, are not simple and homogeneous, and incapable of farther analysis, as Newton erroneously supposed, but are farther resolvable. This Sir David Brewster confirmed by his experiments, conducted with great skill and care. But the objection to the unchangeability of refracted light has been unanswerably met by Dollond's invention of achromatic glasses, and confirmed by the researches of Euler and Klingenstierna. ANTONIUS LUCIUS gives the simple experiment of placing two sticks, one painted blue, the other orange, in a vessel of water. If the different refrangibility of colour were true, then these coloured sticks ought to bend off differently, but they do not do so, they retain their position. How is this difficulty to be solved—how to be reconciled with the theory of different refrangibility? Another experiment I take from Goëthe's *Farbenlehre*, p. 435, where

* Encyclopædia Britannica, tom. xiii., Opticks.

he says:—"Take a piece of tin, and paint the prismatic colours in successive order on it, painting the ends black or white, or some other colour; place it in a vessel, so that it cannot be seen, and then fill the vessel gradually with water: the colours will successively appear on the edge of the water raised up by refraction, and which, had they different refrangibility, could not be. This experiment, simple as it is, destroys the groundwork of Newton's theory; and in dealing with the celebrated "*Experimentum Crucis*"—the sixth experiment—Goëthe further shows, with great acumen, the unreliability of this celebrated experiment. "The error," says Goethe, "Newton allowed himself to be betrayed into was, by insisting on that which he must have felt to have been, at the very least, uncertain." The act of refraction does not absolutely displace the first image; it still remains present, accessory to the refracted image, overlapping its edges. The two spectra produce yellow or blue, according as their borders are drawn from dark to bright or from bright to dark. I will name another test given by Antonius Lucius. He placed two differently coloured silk threads under the microscope. According to the theory of Newton, they ought not to appear both at the same time clearly visible, but the one first, the other subsequently, obeying the law of different refrangibility of colours; but both are seen simultaneously. He then justly infers that Newton's theory is wrong—that colours are not differently infrangible, as supposed by Newton. In treating of the different theories, it is no easy task to confine the inquiry within strict bounds, to avoid handling in detail points of controversy, or essential facts upon which theories have been founded; I may, therefore, be in some manner justified in having devoted the space I have given to the discussion of the respective merits of the undulatory and emissive theories. The emission theory

—in as far as it supposes a fluid, a material something, and which even Newton hesitated to describe as a substance emanating from a luminous centre, the rays of light conceived as containing within themselves synthetically, compositely, the primary colours—certainly fails to satisfy the objection raised by Huyghens and others. It fails, too, in explaining the polarisation of light, and the wonderful discoveries in polarisation since made: the coloured fringes of Grimaldi, the double refraction, the unanswerable objections of Goëthe, and the changeability of the prismatic image. These phenomena confirm the views of the modern school, and farther gainsay Newton's theory. I need hardly repeat the phenomena already mentioned in the chapter on the undulatory theory—they are patent to all who are familiar with the science of optics.

In closing this part of this chapter, I must, however, allude more fully to the celebrated "*Experimentum Crucis*," the sixth problem or experiment of Newton, which I have already referred to. The coloured image, says Newton, of the second prism can be moved up and down by turning the first prism round about its axis; and the coloured parts of the image can be transmitted through an opening on the second board. He then observes that the light tending to that end of the image towards which the refraction of the first prism was made, suffers, in the second prism, a refraction considerably greater than the light which tended towards the other end. From this he inferred that the true cause of the *length of the image* was discovered to be, that light, instead of being homogeneous, consisted of rays of different refrangibility, and that, without any difference of incidence on the same medium, they differently refract: hence he concluded that only the middle kind of rays are effected by the refractive powers of water, glass, &c.—establishing the rule, that the sine of incidence

of light is to the sine of refraction in a given determinate ratio. Goëthe, as already stated, absolutely denies the correctness of the experiment; and I refer those who may be more interested in the controversy, to the polemical pages of that author.* I cannot, however, refrain from rendering the salient points in controversy, as given by Goëthe.

Firstly, the experiments are proved to have been conducted under circumstances, and subject to conditions, that materially interfered with the results. Goëthe justly remarks that it is dangerous to prescribe rigid rules in dealing with nature. The aperture into the dark chamber need not be pinched into a mere infinitesimal point. The prism ought to be large, and sufficient light admitted, to allow fair play to the experiment. Newton, evidently with a view, says Goëthe, of proving his own theory, tortured his experiments until they fitted to what he required them to prove. The six questions he puts show the bent of his mind. I will give them in abstract. First, Has the thickness of the glass aught to do with the experiment? Newton replies in the affirmative. Goëthe absolutely denies this, and sustains his negative by unanswerable facts. The second I leave unnoticed; but the third question is of more importance—namely, whether the margins of light and shade affect colours? The whole of Goëthe's theory is based upon the mergence, the shifting of a dark surface on to a light one, and *vice versa*. Newton, on the contrary, denies the effect of shade on light, or light on shade. I translate Goëthe's own words *(Farbenlehre, tom. ii., p. 410)* in reply:—"How and in what manner Newton convinced himself of the contrary, that the margin of shade had no influence in producing colour, must strike

* Farbenlehre, tom. ii., p. 433; and see also figure 12 of plate 1.

every one not utterly devoid of truthfulness with amazement, nay, horrify them; and we ask of all our readers, hostile and friendly, to thoroughly examine the facts." There can be no doubt that Newton was in the wrong; and the simplest tests may be readily applied to verify the statement of Goëthe. The fifth and sixth questions, however, arrest our attention:—Has the difference of angle of incidence from the top and bottom of the image of the sun, aught to do with the phenomenon? and, Do the rays proceed in curved lines after refraction, and by this means prolong the spectrum? With some truth, Newton attacks Descartes' globular rotatory theory, borrowed from the movement of a ball struck by a bat, and replies in the negative. Having removed the obstacles presented by the questions just enumerated, he at once opens ground, and states his theory of innate colours residing in light, and with which I have already dealt.

Light and Shade Theory.

A GLANCE at the theory of Aristotle, of Antonio de Dominis, though rendered in the historical introductory sketch, may guide us as we follow the reasonings of Goëthe in his celebrated treatise, "Farbenlehre" (1810, Tübingen). I will in part extract passages from these pages. Simple colours, says THEOPHRAST, are those that accompany the elements—fire, earth, air. The earth and air are in their natures white; fire and sun, yellow. Primarily the earth was white, but coloured by sunlight. Black colour accompanies the elements in their transition from one state to another. With what prescient power the old philosopher trod upon the ground of the great truths which chemistry and the discoveries of the day have brought to light.

though conveyed in the symbolic language of scientific expression of that period. Colours are formed by the mixing of light (white) and darkness (black); and the degree of this intermingling determines yellow, red, violet, green, &c. This κρασις, as Aristotle tells us, is the fundamental principle of all colours. The μιχις, in the technical language of Greece and Rome, results in colour. ANTONIO DE DOMINIS says, "Colours arise out of light: of this I have no doubt; nay, they are only light itself.* Add to light some element of shade, but without extinguishing light altogether, and colours will arise." In cap. iii., p. 9, on refraction, he gives to colours arising out of light, the name of *emphatic colours*. Black is not a colour, but the absence of light. In the dark, objects are seen all alike.

Here, then, we find the theory of Aristotle, the μιχις of the ancients, resuscitated; for, after all, there is a great truth in many of those early theories, which need but studying to become adaptable to the advance of the present day. Goëthe grasped this: he felt that in the light and shade of Theophrast, Aristotle, and De Dominis, there lay hidden a secret spring of knowledge, which needed but uncovering to yield a full supply of mental, ever-reinvigorating life.

And what does Goëthe say? "Colours are divisible into physical, physiological, and chemical. The first are ever inconstant, volatile; the second, transitory; the third, permanent to the very last."†

To produce colours, light and shade are necessary; that is, light and no light—if a fixed formula must be employed. Blue and yellow stand at the opposite poles of the schema

* De Radiis Visus et Lucis, 1611.

† Farbenlehre, tom. i, Introduction, p. 40-45.

of colours; and their commingling forms green; and all the colours of the prism are produced out of the primary colours. Colours are half-shades, demi-lights; hence, when mixed together, they produce a grey, not a pure white light, as erroneously suggested by Newton.

But, farther extending this theory, Goëthe has suggested, with wonderful acumen, that a limitation, a boundary to light, by shade, is the cause of colour. At the edge of the coloured image he seeks the law. *(Farbige Schatten—Coloured Shades—tom. ii., sec.,* 69.*)* Colour is in itself a shade—σκιερόν, the *lumen opacatum* of Kircher—and combines readily with shade. Colours are the products of light. *(Thaten des Lichts.)*

Light in itself is colourless; but, when seen through a dim medium, it then becomes coloured yellow; and, as this dimness is increased, the colours deepen and change to red, to ruby red. Whilst if darkness is seen through a medium already dimmed, but illumined by a light falling on it, blue is observed, and, if the medium increases its dimness, darker and fuller.

In the division of his subject—the chapter on physiological phenomena, or I may be allowed to designate them subjective phenomena, of the visual organ—Goëthe justly allows to the organ of sight a part in the act of creating colours—a fact too much overlooked by others, who seek only the mathematical properties of light, and forget that the retina and the optic nerve play their part. Light reacts as shade upon the retina, and colours have their complemental reaction: for instance, green produces red, purple, &c. Again, the eye in darkness operates differently than when stimulated by the presence of light: a feeling of vagueness, of looseness, supervenes. Keppler says with truth—"*Certum est vel in retina causa picturæ, vel in spiritibus causa impressionis existere dilatationem lucidorum.*"

The eye asks for light so soon as darkness prevails, and darkness where light is present. The systole and diastole of nature is present in all the phenomena of life, so also in those of light. In coloured shades—which are produced by a sub-light either of the surface reflected from, or by the presence of a secondary light, the presence of artificial light—a farther proof is furnished of the activity of the two primary states in producing colour. The most beautiful coloured shadows are to be observed at full moon, by the aid of candle-light falling upon a pencil held over a white surface. In this instance the conditions for the production of the phenomena are perfect; the reflected sunlight of moonbeams allow the full colour of the deep blue shadow to be observed, without the overtoning of the eye by the brilliant presence of sunlight. Pathology likewise teaches us interesting lessons. The sparks and flames seen by the patient during inflammation after an operation; the halo of light seen in amaurosis; and those instances in which patients are unable to distinguish certain colours—are by no means rare phenomena, and point to a subjective action of the eye. Zambeccari says that he saw the moon red at a great elevation. I am only instancing these facts in confirmation of Goëthe's theory of the importance of the subjective action of the organ of vision.

In treating of physiological colours, Goëthe opens up an important subject; and in this part of his work, sections 150, 151, he developes his theory of the production of colour out of shade and light. Dioptric colours, katoptric colours, paroptical colours, are all explained by the intermingling of light and shade, produced by a limitation to the field of light by shade. I cannot do more than allude to these chapters; that which has been said in dealing with the phenomena of reflection, refraction, and inflection explains, as far as requisite for this Treatise, the nature of these

optical effects. The chemical colours, to which he has devoted a chapter, however, arrest our attention. I can hardly do better than translate the section on chemical opposites. He says (section 491):—"In giving a representation of coloured appearances, we had to call attention to an opposite act as the cause of colour; similarly we find, on approaching chemical ground, chemical action meeting us, with marked significance, as an opposite." Here, then, at last, we gain a step in the right direction—colours are produced by a change, a change resulting from a polaric act of arrestation: yellow and red-yellow belong to the acids, blue and red-blue to the alkalies. The operation of acids upon metals, one of the most fruitful creators of colours, proves that in the presence of colour a change by oxydisation has been, so to speak, indexed. Chemical colours indicate an alteration which the reflecting surface has undergone; they point to a law intimately connected with the production of light, and which the theories of Huyghens and Newton have not explained.

"Light is never absolutely pure," says Goëthe. It may be added that the very passage of a beam of light through the lens of the eye darkens, colours; the slightest change in the condition of matter—such as pressure, heat, and rotation—produces colour; colour indexes these mutations, alterations, and transitions. In treating of light and colour, and the act of vision, the mind is only too apt to sever the three great functions that follow in their operation, and upon the harmonious action of which light and colour are dependent. The organic action of the eye, the transition of light into colour on the retina, and the chemical character of bodies, are necessary to the production of colours, and without which we should have no knowledge of their presence.

I must now conclude the remarks on the light and shade

theory. The polemic chapters of Goëthe's great work, in which he follows Newton step by step, disputing every inch of ground, is too voluminous even to allow of fuller reference; hence, those who desire to enter more closely into the questions raised will have to use his works for farther information.

The great error (here I concur with Goëthe) has been, and is to this day, that colours and the phenomena of light are treated as entirely within the bounds of mathematical reasoning. Nothing can be more erroneous, more apt to mislead: light has other characteristics besides its properties of movement, of reflection, refraction, and the numerous phenomena already dealt with; colour belongs to nature, as one of her fairest attributes. Light is a great *chemical agent*, has properties, powers of its own, which neither mathematician nor optician can grasp: light is only seen by an organ of vision.

I will now furnish a summary of the theories as they stand recorded by the different schools; and in doing so, I render them in their chronological order:—

1. The Aristotelian theory—that light and shade are the producers of colour—that colours only manifest their presence in light.
2. The Platonic theory—that colours arise from minute luminous flame points, which, so to speak, are flung into the eye from the object seen.
3. The school which, though rejecting the luminous emanation theory, yet contends for an efflux, a fluid passing from the object seen into space.
4. The more modern view—that light and shade produce colours.
5. The chemical explanation—by which sulphur is the primary producing element, sal the secondary.

6. The Cartesian theory of luminiferous globules rotating in space, and producing colours according to their increased or diminished velocities.
8. The Emission theory, as propounded by Newton and his school—the pre-supposing of a fluid in space, possessing all the qualities of matter but that of weight.
8. The great theory of the day—the Undulatory theory. It stands alone—needs no comment. And lastly—
9. EULER'S theory, subsequently extended by Grove*—that light is produced by a change in the molecular arrangements of the atoms themselves, from vibration or motion of the molecules of matter itself.

It is pleasurable to find Mr. Grove fearlessly asserting these views of a distinctive line of thought, though perhaps clashing with the adopted opinions of the day.

I have now approached the end of my journey. I have passed the cross-paths of the advance of knowledge on the road. The inquiry into the nature of Light has steadily progressed century by century; thinking minds have again and again resumed the investigation; theories have been met by theories; controversy by further research—until, by the aid of wonderful mechanical skill, by the assistance of delicate optical instruments, facts have been verified, false data rectified, and the way prepared for an advance, a step onward, into the field of knowledge of the hitherto unknown properties of Light.

Frauenhofer, of Munich (1814), first drew attention to the *Spectrum Analysis*. The dark bands were observed

* Grove's Correlation and Continuity, p. 165.

by Dr. Wallaston (1802). Though little noticed at the time, these researches have, nevertheless, resulted in the great step in advance made by Kirchhoff and Bunsen. Their discoveries play so important a part in the researches into the properties of light, opening (according to the adopted theory of the day) the door to an insight into the chemical properties even of stellar bodies themselves, that a few pages may be advantageously devoted to the results of the researches of these great explorers. I do this the more willingly; for, though I may differ in my conclusions as to the cause of the dark lines or bands of the spectrum, and hesitate in accepting their presence in proof of certain substances on the sun's surface and on stellar bodies, nevertheless, I hail, with all the warmth of true recognition, the great discovery, which must lead to farther and profounder knowledge of the laws of light. What is this spectrum? I will describe it; and must be excused for doing so, because it aids the mind to have the image in clear outline before our mental view.

A solar spectrum from a narrow flint prism, seen through a telescope, was found by Frauenhofer to contain stripes or dark lines between the colours, in some instances subtending at an angle of 5″ to 10″. So distinct were these bands, and so constant, that Frauenhofer lettered them A, B, C, &c., which mode of arrangement has to this day been retained. It matters not what the size or length of the spectrum may be, the dark lines remain constant. But what adds to their interest, is, that planets, stars, and comets also, when examined by the spectroscope, have dark bands; so also the flames of artificial and electrical light. By means of these fixed lines or bands in the spectrum, we are enabled to measure most accurately the refractive and dispersive properties of bodies. The illuminating and the heating powers of the spectrum, both of

which have been accurately determined, give us another step in advance—blue showing, according to Sir Henry Englefield, 56°; red, 72°; and beyond red, 79° of heat, Fahrenheit. But chemical energy had also been observed. Dr. Seebeck instituted a series of experiments with muriate of silver, obtaining very satisfactory results—the violet colour, and the violet line beyond, being the most active agent in darkening the salts of silver. MM. Carpa and Ridolfi, though refuted by Riess and Moser, have given a series of experiments proving the magnetising power of the spectrum.

In 1836, Professor Forbes, in his observations on the annular eclipse, ascertained that the dark lines could not be the result of the absorption of the sun's atmosphere, the bands being neither broader nor more numerous in the spectrum during the eclipse than at other times.

Thus far advanced was the knowledge of the spectro analysis, when Kirchhoff and Bunsen directed their attention to the dark lines of the spectrum. Schwabe had previously noticed that yellow bands were produced by adding a small quantity of salt to the spirit lamp. In 1860, Sir David Brewster and Gladstone had, adopting the views of M. A. Mathiessen, suggested that the dark lines were attributable to absorption in the sun's atmosphere. Profitting by the advance made, Kirchhoff and Bunsen vigorously set to work to ascertain the effect of substances on the spectrum. That their success was complete, I need not mention. Once the principle established, that substances such as salts and metals present in the flame of a burner—it mattered not how minutely—produced bright lines in the spectrum corresponding to the substance present, a wide field of inquiry lay open to the discoverers. The most delicate chemical tests could now be made by the aid of light. Kirchhoff ascertained that a percussion

cap of lithium, detonated at some fifteen feet distance from the burner, produced a change in the flame. Arago justly says that each metal has its colour. *How* wonderful this discovery! Yet another awaited these philosophers. A ray of solar light, made to impinge on the ray of artificial light of the burner, extinguishes, so to speak, part of the artificial light; or, to render this in more scientific language, "the power of absorption is equal to the power of emission." From this Kirchhoff and Bunsen inferred that the darkening of the lines in the spectrum, indicated the presence of a metal on the body of the incandescent nucleus of the sun; that the luminous vapours which enclose the solar body, absorbed these rays; and that, on reaching the earth, the solar rays act negatively on the spectrum—that is, darken the bright lines, which had become brightened by the presence of incandescent particles of metal in the flame of the burner. From this they inferred that the spectro analysis would show bright lines in lieu of dark lines, but for the absorbing power of the vapour envelope of the sun. For instance—silver, gold, mercury, aluminum, silicium, cadmium, lithium, and many other substances, are not affected by sunlight; and the inference thus goes to the length that none of these substances are present on the surface of the sun. M. Faye *(Comptes Tendus*, 23rd January, 1865*)* gives, in his excellent treatise on the "Spots of the Sun," his observations on the "*faculæ*," or bright ridges that traverse the solar spots; and he observed on the edge of the sun's disc, flames, red in colour, and 70,000 miles in length. He also endeavoured, by the incandescent theory, to account for these phenomena of solar flames; and I mention his name, and those of Mayer, Carrington, Huggins, Tyndall and Tait, to show how firmly the incandescent theory has hold of the scientific mind of *the day*. The uprush of hot air, or

vapour, of Faye's theory, displacing the luminous clouds of the sun's photosphere, and the upward current of hot air, and downward current of cold air, according to Carrington, are only forms of thought proving how strongly the intellect of the age is bent upon inductive methods to explain physical facts, and the desire to reason by analogies taken from our earth's nature.

I should be doing injustice, if I did not mention the names of Lockyer and Balfour, and their sun-energy theory. Though deficient space had restricted them, and, no doubt, hedged in by the limits of the periodical in which their article appeared;* nevertheless, they make an advance upon the theories based upon mere mechanical or physical action of bodies,—theories I do not cast aside as useless, but must warn their devotees that they lead to extraordinary, contradictory, and unsatisfactory results. Galileo Schwabe,† Scheiner, and Fabricius, must be also named in connection with the study of solar specs.

The total eclipse of the sun, 18th August, 1868, has given an opportunity for spectroscope analysis, and it is as well to mention some of the results of the numerous observations.

I will commence with those of Major Tennant, contained in his letter to the well-known spectroscopist, Mr. Huggins, F.R.S., and Secretary of the Royal Astronomical Society. The polariscope, says Major Tennant, showed, according to Captain Branfili, that the light from the "corona" was strongly polarised everywhere, in a plane passing through the centre of the sun. This, according to the spectroscopic

* Macmillan's Magazine, July and August, 1868.

† Science is greatly indebted to his perseverance. For forty years of his life, he constantly observed the solar specs; and it is from the observations he has made, his successors have been enabled to make a step forward.

theory, proves that the corona is not self-luminous, but owes its light to the body of the sun itself, the light of which it reflects; whilst the light from the protuberances, I have already alluded to, was not polarised, proving their proper self-subsisting luminosity—the corona showing a continuous spectrum; the protuberances giving bright lines in the spectrum. The inference is, that sodium (the line D of Frauenhofer) is present as one of the principal matters in the spectrum; the line F, or hydrogen line, being likewise effected, proving the presence of this element.* From this Major Tennant infers that burning sodium and hydrogen in an incandescent state are contained in the protuberances. This theory has some confirmation from Lieutenant Herschel's observations on meteors (Aug., 1866), which satisfied him, by spectro analysis, that they consist chiefly of the vapour of sodium, or sodium flames, similar to the flame in Bunsen's burner, when freely charged with sodium. From these facts Herschel draws the following conclusions:—namely, that the atmosphere around the sun consists chiefly of non-luminous, or faintly-luminous, gases, at a short distance from the body of the sun itself; and that sodium and hydrogen are the dominant materials in an incandescent state. The polarisation of light in planes passing through the sun's centre, has been confirmed by other astronomers.† Lieutenant Herschel says he could not observe distinct indications of a spectrum

* May 2, Huggins examined by the spectroscope the comet I, and his result is startling—namely, that the luminous body consists of incandescent vapour.

† 18th June, 1868.—Dr. Miller, F.R.S., the eminent chemist and spectroscopist, fully satisfied himself that Winnecke's comet consists wholly of, or mainly of, volatilised carbon. In 1864, Huggins had observed several bright bands corresponding to substances of our earth in the spectrum of Winnecke's comet.

belonging to the corona, and he justly concludes that it was a fainter image of the sun.* In this I fully concur. The sun's image, screened behind the body of the moon, could not focalise the rays so as to produce the full effect: hence the fainter image. The full white light of the sun is the effect of the total polaric action of light emanating from the solar body; where this is disturbed, the image must be not only fainter, but changed.

Another theory is extant—that numberless meteorolites and undetected comets exist in the perehelion of the sun, and shower down a perpetual hailstorm upon the sun's surface, which blaze up in flames, producing the appearance of the corona and protuberances. The facts are, however, opposed to this theory—namely, the perehelionic approach of the comets, which appear at one time all but lost in the sun's disc, and then re-emanate from the central body. How is this eccentric motion accomplished? Some law of repulsion must exist; or else, why do comets return into space?—why are they not absorbed into the central body? If this attraction and repulsion be regarded as an electrical act—(I use the word electrical for want of language to express the truer meaning, well aware that electricity necessitates the presence of matter to produce the electrical fluid, and that to speak of electrical forces presupposes these)—the mystery of solar attraction and repulsion may be in part accounted for, and the action of solar light accepted, not as emanating from an incandescent

* The relative character of stellar light and solar light is of great importance; and if a spectrum of a star could be formed (perhaps in a deep shaft), and a ray of sunlight thrown down by reflecting mirrors, we might be able to ascertain the direct effect of sunlight upon star light; and which, I maintain, ought to give results quite different from those of sunlight acting upon a spectrum of an ordinary (artificial) burner.

body, but resulting from primary electrical ether forces, accompanied by the polaric character already alluded to. Regarded as such, the spectro analysis would lead to far more important results than it hitherto has done.

The incandescent theory is, to my mind, very unsatisfactory; and, with all deference to those who have unhesitatingly adopted it, it misleads and bewilders. If I might be allowed to hazard a theory, I would suggest that the sun-spots, the faculæ that traverse these, the corona, the protuberances, those flame points of immense length, are all electrical phenomena, and alternate in light and shade, as the positive and negative poles act and react upon one another, proportionably as the transitions into light, by final combination at the heliotrode, take place—the flame points only indicating the outstreaming of the electrical ether wave of light in the direction of the planetary bodies the solar powers supply. In this view I am confirmed, by the fact that sun-spots increase whenever Venus and Mercury are in conjunction in their perehelion.

The spectro analysis takes us beyond the limits which science can safely admit, and as the inquiry is pushed onward to new fields of research, quite inexplicable contradictions arise. The conclusion arrived at—that comets are composed of hydrogen or volatilised carbon, as is supposed to be the case in Winnecke's comet—the attributing of properties to stellar bodies, a parallelism of material existence to that of our earth, and upon a very narrow analogy—is certainly unsound. Even fixed stars furnish, according to this theory, proof of substances analogous to those of our solar system. Is this not going too far?

With the fact before us, that the specific gravity of the planets themselves varies—(the specific gravity of Saturn is equal to that of cork, the specific gravity of the sun greatly less than that of our earth)—it is not unreasonable to

suppose that laws differing with those of our globe regulate the material formation of these spheres, and which no doubt are differently constituted, and held together only by the universality of the dynamical, physical forces, of which light gives us a marvellous, repetitive instance, in the presence of far distant fixed stars, and those nebulæ and clusters of stars, which the telescope can only but just resolve into groups of stellar bodies.

CHAPTER IV.

Resumé of Dr. Johann Fred. Jencken's Theory, 1837, 1852, 1862.

I HAVE now my final duty to perform. I have given in outline the theories of the many thinking men who have laboured for an advance on the field of science—have theorised, experimentalised, and, though often at variance, diverging into different currents of thoughts, have, nevertheless, aided in the onward struggle in their researches into the nature of light. My task has thus become limited to the rendering, in an abstract form, the theory of Dr. Jencken. Let us learn what he has to say; and I give the following in my own language, though conveying his thoughts.

An "Urelement," a primary ether, formative, plastic in its character (says this author), derived from the totality of all the cosmic and pancosmic worlds, nourishes and supplies the solar system, the planets, satellites, and even the smallest cell on the earth's crust. The sun itself derives its never-ceasing supplying influx of force from this cosmic ether influx. It hence becomes necessary to determine what are the characteristics of this primary ether (urelement), how manifested in nature, and more especially in what manner represented in the phenomenon of light.

Light and ether are primary finest, most primary transition elements. Motion also is a materiality, and every transmutation of a force into a physical function must assume a material form. This materiality is the necessary mediation

of the primary creative power. Light is only one of the many transition forms of this primary ether power. The primary ether is, however, only a generic term, indicating a state of things symbolical of elements more primary than the elements of our terrestrial nature, and is composed of infinite finer and varying ethers, in a perpetual state of transmutation, change, and progress. This change, transmutation, is, however, mediated by a pre-existing state of things; mediation throughout plays an all-important part. Light is mediated by the presence of the telluric powers, arrested, and, by means of this arrestation, the luminous ray is formed. The primary ether state of the solar power and of stellar power is not light: it only becomes so by the centralising effect of telluric resistance.

But the eye itself performs an important function;* the eyeball not only acts as a crystalline lens, centralising the rays, but forms out of light itself an inner organic ether light, which, first, mediates the influx of the outer light, and, secondly, mediates the ingress to the higher nerve centre of inward vision. The eye arrests light, digests it, and then transmits it to the brain.

The crude idea of regarding the eye merely as an optical mechanism, the author utterly repudiates. On this inward light Dr. Jencken lays great stress, and attributes the imagery in dream, in fever, delirium, and madness, to an inward organic light. The eye, in sleep and abnormal conditions, cannot control this inner light, and hence it forms an imagery of our inward sense.

Light is essentially polaric in its nature, as proved by the prismatic colours; and the dispersion of light is not, as erroneously supposed by Newton, a splitting-up of a pure

* See *Treatise on the Eye* at end of Chapter.

white ray, but a polaric unfoldment of the ray of solar power; and every substance, though obeying a general ruling law of light, develops it in accordance with its own proper materiality. The spectrum analysis furnishes the best evidence on this score, and thermal and chemical properties attend the phenomenon of the spectrum.

Light being formed by a transition from an inner finer ether element—the antecedent state is that of turbidity, not light—the transition states are marked by colours. Each colour, therefore, contains the possibility of being transformed into any other colour; and the reconstruction of white light, upon which so great a stress has been laid by the Newtonian school, is nought but a recentralisation artificially produced by the lens. So true is this law of retarded, arrested light, that the ray itself, as it pulsates through space, becomes alternately luminous and dark. "Light," to follow the words of the definition given by Jencken, "is an excited axis of direction of points, changed along its course, and which we recognise as a ray of light —a lighting-up in thousand upon thousand successive points of ignition." In light, a constant tendency prevails to pass into some other state of elementary condition—this is manifested as an obscuration in its negative state; concentration, combined with swiftest motion, representing, on the other hand, the positive state. The bars of the spectrum, first noticed by Frauenhofer, are, in fact, the negative boundary lines of coloured rays developed by the prism. Chemical colours, or the surface colours of bodies, reflect light changed in its nature—changed in obedience to the same law that regulates the formation of prismatic colours, "polaric unfoldment of light by contact with a body," though, of course, not in the same order of succession.

One constant law regulates the development of light,

that is, its polaric nature. It is to this law we must look for an explanation of the prismatic colours; the appearance and extinction of luminous rays; the absorption of light. Shade is not only an absence of light, but represents its negative state; and hence the correctness of the light and shade theory of Goëthe; the transition on the border line of shade and light; the coloured fringes, the effect of a boundary line enclosing light; a limitation, resulting in a change, transition.

The presence of oxygen in light—the oxydising property of light producing colour in all growing, developing forms of nature, and its bleaching effect upon decaying substances—gives to light the character attributed to it by Dr. Jencken, namely, that of a transition from an inner ether state to a material concentric form. The primary ether of the solar power is concentrated into light, then passes into other elementary dynamic states, such as heat and electricity, but, above all, into oxygen. This gas permeates the whole of the earth's crust, is present in every created form of life, never at rest, changing into azone; with its polaric character of negative and positive, forming leaflet, and water, and rocks, and travelling onward, in never-ceasing energy, until re-dissolved into ether, and the transition into another elementary grade is completed. The laws of combination and resolution are invariably the same; hence the polaric unfoldment of a beam of light of a candle, or jet of gas, resembles that of the solar ray; but this semblance is only in form, not in essence. It is not the pent-up light of ages, as Stephenson tells us, that is freed, and burns up in our coal fire; but, on the contrary, it is the revolving of the substance through all the prior states back to its ether form, but with a negative character, which we observe in the artificial flame of a candle, or jet of gas; hence the effect of the solar ray in Kirchhoff's

and Bunsen's experiment—namely, it darkens in part certain portions of the spectrum, the negative action is complete.

With these remarks, I will proceed to give a summary of the theories I have endeavoured to explain. First,—According to Dr. Jencken, light is not a permanent, material existence, emanating from a luminous centre; but, on the contrary, light is a *state of transition* from an inner primary productive ether, rendered plastic by the concentric act of the solar power, and adapting itself, by this centralising operation, to the use of the material ponderable world.

Secondly,—The presence of a passive ether element, necessitated by the undulatory theory, so constituted that it can receive every impulse, and vibrate it onward into space spherically, is quite inexplicable, though light may possibly be impelled on undulatory waves through space. This undulation results from a molecular change in the atoms themselves, manifested in alternate impulse and arrest in the luminous points on the line of direction of the ray. The reason why light is communicated in rays, and travels in straight lines, is that of its peripheral character. Each moment strives to attain its farthest limit, but on all sides, and in this act, narrows laterally the surrounding moments that are doing the same; hence the pencil form of a ray of light, and the travelling in straight lines.

Thirdly,—Light is seen, is absorbed by the eye, mediated by the presence of an organic light, formed in part from the external light that has already been mediated in part from the ether light of the organ of sight itself; hence a subjective act is absolutely necessary, and without which we could not see.

Fourthly,—The ether state *preceding* light is dark; the elementary state following upon light is again obscuration;

the transition from the first luminous moment of primary so-called pure light, polarically manifested, is the coloured spectrum of the prism. Colour is, therefore, only a form of transition of a power arising from an intrinsic "urelement;" combination and resolution obey the same laws, and pass through the same elementary states, present similar phenomenon of dynamic physical forces.

The inner fire Plato alludes to—the πόροι of Empedocles, the watery channels, or, to use the language employed by Dr. Jencken, the organic ether element that surrounds the eye, and which he lays so great stress upon—Plato and Empedocles understood; and I allude to their theories with satisfaction, for it is so instructive to follow the development of each branch of science, and, more especially, to sound the depths of the philosophical ideas of the Greek. The intuitional, often quaintly expressed, thoughts of all but forgotten philosophers, rise again and again to the surface, and after ages of oblivion, aided by the advance of subsequent researches, re-enter the intellectual organism of the present period. Dr. Jencken's merit lies in his boldly taking up independent ground—his adopting a physical dynamic character for light, and asserting that light is not a permanent, divisible materiality, but, on the contrary, a form of transition, manifesting itself in comprehensive, distinctive laws, known to us as the colour, chemical, and physical properties of light. He does not reject the undulatory theory, inasmuch as it deals with a vibration on the axial line of direction, but he questions the existence of an ether, passive, and merely acting as a medium for conveying undulatory impulses.

The subjective act of the organ of vision itself, the mediation of the outer light by the presence of an inner organic light, is an original thought he may justly lay claim to; and the study of the laws that regulate this

union of the inorganic and organic light must conduce to the understanding of other laws we, hitherto, can only guess at—those of the brain function itself, in the act of seeing.

Conclusion.

I HAVE thus far rendered the theories of Dr Jencken, and have endeavoured to place saliently before the reader the ideas he has adopted; and would here conclude, but desire to state the views I have adopted upon the phenomena of light.

The great difficulty to my mind is the extension, the act of dispersion, of light on all sides. Given a luminous centre, why does light leave the central body, and travel spherically on all sides into space? The emission theory is most unsatisfactory. The undulatory theory, in as far as it necessitates a common, all-pervading ether element, has been justly attacked by Euler and others. A change in the molecular particles or atoms, on the axial line of direction, of a ray of light—and which Grove renders with great acumen—compels me to admit final atoms, and which I cannot concede. How, then, I ask, is this luminous sphere filled? Would light travel onward into space, supposing the originating luminous centre suddenly to become extinguished? If the wave motion, once set into activity, propagates itself by the mere force of pressure of wave-points upon an ether fluid seeking its normal rest—then, according to this theory, once set in motion, the luminiferous wave jerk, as Young designates the undulation to be, would continue, irrespective of the luminous centre. Another question: A ray of light can only be luminous at its farthermost and final point; the distance gained, admitting

hypothetically that the light from the luminous centre had been shut out, would be in darkness—the wide expanse a dark void, with a minute wave undulation on the extremest peripheral extent of the luminous sphere; whilst the sphere would be widening with immense speed, until its bounds could be measurable only by millions of years of the travelling of light. Is this theory correct? and, if correct, is there no connection between the extremest points of the periphery of the luminous sphere and the central body?

My contention is, that there does exist a most intimate connection between the central and the peripheral; that the former sustains the latter; that take away the sun, and sunlight would cease instanter throughout space! Admitting a connection, What is it? how sustained?

Undeniably, the ray of light in farthest distance is still sun power, or stellar power, or vialacteal power. Nay more, these very rays that pulsate through space translate, to use Whewell's expression, into other forces—heat, electricity, magnetism; produce chemical effects.

What connection, I repeat, then, exists between the sun and the terminal point of its rays? I am driven by these questions to accept two alternatives—either a severance of sun power, a parcelling off of its substance, and pouring it forth, it matters not how, by undulatory waves, or in straight rays, accompanied by fits *(Newton)*, into space, and a consequent severance, after propulsion, like an arrow from a bow; or that a connection exists continuous between the *heliotrodal* ether fluid, at its centre in the central solar body, through the whole length of its axial line of direction, at every point of the sphere that light reaches;—in other words, that the extremest distance light travels is actually the peripheral of the solar power itself, but in an ether wave form of solar power, continuous in its existence with the solar body, and perpetually renewed from the central body.

But if the centre and periphery coexist, and depend for their existence one upon the other to form a totality, the space that the rays of light have travelled over must be filled with solar force, coexisting in space with the ether fluids of other solar powers of stellar bodies; for endless numbers of suns, and belts of suns, exist in space, all pouring forth their forces into space, intermingling one with the other;—in other words, the peripheries of the different solar bodies coexist in space, each self-existing, undisturbed by the presence of the peripheries of other suns. This coexistence, however, could not possibly be, if all the suns in space were created of one uniform common material. Matter cannot occupy the same space at two different points, and space cannot contain two materials within the same limits! How, then, to account for the peripheral presence of the many sun powers represented by the stellar bodies in space, without interference one with the others? This brings me to the consideration of the law of gravitation, the *concentric action*, the flow from the extremest peripheral back to the central body.

A parallelism must exist between these two great agents of creation. Bodies might be said to attract one another in the direct ratio of the intensity of their light.

Gravitation and light, according to Schelling, stand polarically opposed to each other, as "*Erste Potenz und zweyte Potenz*," from centrum to centrum, outward and retro, in never-ceasing pulsation. The action of gravitation is all but instantaneous. The sun holds within its attractive force every atom of the earth, and the earth's centre of gravitation binds down leaflet and mountain range all alike. There is a steady, never-yielding hold in the perpetual inflow of the solar, of the earth's attraction, of the attraction of all cosmic bodies, which speaks in unmistakable language of a great dynamic power operating in producing these phe-

nomena. I use the word dynamic as expressive of an imponderable, unseen agency. No distance, however great, without an existent attraction. Given a sun, and that sun will attract towards its centre wheresoever its light extends. The law of the inverse proportion of the squares of the distances of stellar bodies is a law applicable to all concentric actions, called gravitation. The law of excentric action must be parallel in its nature; and in the speed, the intensity of light, the swiftness of motion outwards, there must, I contend, be a law, possibly in the inverse ratio, of the distance of bodies—a law most difficult to ascertain, but which, nevertheless, does exist. Whence, then, does this influx of power arise, denoting a great centralising force? It arises from the inflow of ether waves from the inner existence, indexing a transmutation, a progress towards a further and onward grade of development, a point in advance, the vortex point of the central body, established by uniting the opposite poles of the inflowing stream into one. *Heliotrode* is a name I have given to the sun, as expressive of this concentric action, this combining of two opposites into one, this drawing into itself of the cosmic powers, and, I add, of the intro ether forces, the uniting of negative and positive forces at a vortex point of unison. The solar bodies are supplied from this influx of the inner ether stream and cosmic inflow, and hence the inexhaustible character of the radiating capacity of the sun, of solar rays and light, emanating from this inflow of supplying power.

Sir John Herschel has calculated the influence of the sun's rays. I will merely give the result—space prevents detailed statement:—The sun emits 45,984 times more heat than the earth receives, superficies for superficies. This is based upon the calculation that the mean distance from the centre of the sun to the superficies of the earth is

21,444 times greater than the radius of the sun. By squaring these figures, it will be found that a single square foot of the sun's superficies must heat 45,984 square feet of our planet. These figures become perfectly astounding if we compute quantities by square miles of surface. Whence, indeed, does this tremendous force arise?

The outpouring of light—for so I term the emission of light—spherically, on all sides, into distances beyond measure, is so wonderful, that it is a matter of surprise that this characteristic should not have been more fully and thoroughly studied. The magnitude of the solar action is indexed by the distance light travels. The luminous sphere created by the emission of solar power is not unlike an inflated bladder, the walls of which are immeasurably distant. But this efflux never ceases; light pours forth into space in steady outflow, and wave point follows wave point, the foremost being urged onward by the subsequent outflow from the central body. This ether efflux from the solar body, propelled in wave points into space, becomes, however, luminous only when arrested by contact in a denser and opposing medium. The photosphere that surrounds the solar body is not, as supposed by the incandescent theory, composed of heated and inflamed gases, emanating from a burning nucleus, but, on the contrary, is only an electrical phenomenon. This the sun's spots, and the faculæ or luminous ridges that traverse these, the corona—also the flames (70,000 miles in length) observed during the eclipse, fully prove. They establish the fact of a double action in the sun itself, an alternate change from positive to negative, represented by the dark nucleus and luminous photosphere of the solar body.

The primary act of the solar centrum, the *heliotrode* (as I shall henceforth designate the sun), is to concentrate, unite the dual, instreaming ether power, supplied from the

intro-existing world, and, furthermore, nourished by an inflow from the surrounding pancosmic realms. This primary act, however, does not as yet produce light; the nucleus is, therefore, *dark, non-luminous;* it must be also *cold*—that is, in a state of extreme concentration—and contraction signifies cold. The ether wave once centralised in the central heliotrode, issues forth, characterised by extremest concentrality. This character light retains to the very last; and it is owing to this fact that it travels in pencils or rays through space. The first arrest or check which this outpouring from the heliotrode sustains, occurs in its proper atmosphere, in the "photosphere." Light is then produced for the first time; that is, the concentrated ether wave is rendered susceptible of change, receives henceforth outward impressions, and assumes the plastic character of light. Every impress is henceforth indexed as a change in the ray itself, which now becomes a suitable messenger to transmit the change, and herald mutations to farthermost regions. But this plastic state of light is not a permanent condition—it is merely the index of the transition of the ether influx, passing from an inner state to its condition in the ponderable and visible world, where it takes its place in the material forms of gases, and the products from these. The impressibility of light warns us that it is new born—tells us that it has but just entered the light-indexed material world which we inhabit.

The negative character of light developed in the photosphere, arrested in the medium that surrounds the solar body—which protosphere has been possibly created by the cosmic inflow of supplying forces—is, perhaps, farther produced by the recoil of the outflow of the ether fluid from the heliotrode itself—that necessary polaric reaction which follows, in alternate phases, upon the first act of concentration and expansion. The dual stream of positive

and of negative ether powers, that has been centralised, would, in obedience to this law, act and react in alternate extremest contraction, with corresponding tendency to expansion.

The experiments of Dr. Morichini, and which MM. Carpa and Ridolfi repeated—namely, that violet rays magnetised a small needle—Mrs Somerville successfully confirmed, though contradicted by Riess and Moser, who, having submitted the experiment to the most careful examination, failed in obtaining any magnetic indications. These experiments led to other results: Baumgartner establishing the fact that unpolished surfaces gave a south pole indication, polished surfaces a north pole; and, though denied by Riess, the duration of the deflection of the needle still remains an undeniable fact. A loadstone, exposed to the sun's rays, doubled its magnetic power; and Zantedeschi confirmed this, by exposing an artificial horseshoe loadstone for three days to the action of the sun. *(Brewster's Optics, p. 93.)*

Once changed from extremest positive concentration, and new-born in this physical world, the ether wave travels onward spherically on all sides into space, in undulatory wave points, expressive of its dual character; in straight lines, indicating the peripheral tendency; and in pencils or rays, as denoting contraction. The wave points of the undulating ray, measured in moments of time, might be taken to represent the thrill sent forth from the heliotrode, as it pours forth, again and again, the ether inflow it has centralised in swiftest succession into space.

There is an actual emission from the solar body of luminiferous ether waves, but which only become luminous on being arrested by contact with a resisting denser medium; the negative character also asserts its right, the wave of ether force becomes plastic, fit to receive the impress, and

ready to change in its nature by contact with bodies it has impinged upon.

I must now revert to the arguments I used at the commencement. If it were conceivable that only one wave point travelled from the sun through space, the distance between the farthermost point attained by this wave and the sun would be dark—that is, not light. Such is actually the fact: the antecedent state to light is darkness. No sooner has light formed, than it passes through the polaric unfoldment in colours into other elementary states, and is no longer light. This polaric action is repeated whenever arrest retards light.*

I might perhaps be allowed to conceive that the central act at the heliotrode is constant, permanent, and that the changes undergone are in the peripheral expansion from the central point; and that in the heliotrode an infinite number of central points are held together, until these peripherals have passed through a succession of expansion, change, and reflex, back to the central body. I would not hazard this theory, were it not for the ex-

* The twinkling of stars has been variously explained, and the interposition of particles of vapour suggested as one of the reasons that produce this phenomenon. Others, again, suppose the unequal refraction of light, the atmosphere being unequal, or undulatory. *(Michell and Muschenbrack.)* To me the explanation appears to be this:—Starlight is a foreign element, negative in its character, or, at all events, different in its character to sunlight. The ray of starlight, entering the solar halo contained within the planes of the orbits of our planetary system, becomes absorbed, checked, though arrested only momentarily in its course. This arrest, check, causes an alternate state of darkness and light, representing negative and positive—the latter, namely, the positive, constantly succeeding to the former, the negative, by the mere act of accumulation of wave points; the supply, influx, doubles its force, and breaks forth in a farther advance, until again checked, arrested, darkened; the alter-

treme difficulty presented by the spherical expansion and boundless extent of light. The undulatory theory is wholly unsatisfactory, as it pre-supposes a positive ether element resting in space, ready to carry undulatory impulses in all directions. The emission theory of Newton and his school fails to explain the phenomenon. Euler, Jencken, and Grove only describe the act of transmission by molecular change. Yet there it rests, this wondrous phenomenon of light travelling onward into space spherically, encompassing immeasurable distances. I hence hazard a theory which I state with a considerable degree of hesitancy, namely, that the primary points of union, the primary central points, which the heliotrode has centralised from the instreaming powers of the cosmic and intro-ether world, remain constant for, possibly, to us, immeasurable periods in the solar centre itself. That the solar orb is fed and sustained by this concentration of ether forces can hardly be questioned (for, where else does the supply come from?); and that each combination, concentration of the dual instreaming of the ether influx, results in an outflow from the centre. This efflux is

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nate states being marked by *twinkling*. I am confirmed in this view by the fact that planets—for instance, the beams of light from Uranus, though only of the seventh magnitude—do not twinkle; the satellites of our farther planets, the Asteroides, though only visible by the aid of a powerful telescope, do not twinkle; and this because the reflected solar light from these bodies travels through a space filled with a solar ether element akin to its own: the reflected light travels in the sun periphery of the solar system. I suggest, too, that the twinkling of fixed stars might be used to ascertain the relative negative and positive character of stars. Possibly the time periods of the outflow of forces from the central self-luminous bodies might be ascertained by marking the intervals between the twinklings. The disappearance of stars is not a destruction of the stars, but only an alternate negative and positive state of the light of fixed stars.

manifested as light. The peripheral expansion continues until the central primary point in the solar body itself undergoes a change, a change produced ultimately by the reflex action of the peripheral back to the great central itself.

There thus exists in the solar forces a dual action which is continually going on: the central act—the uniting of the inflow of the primary ether powers supplied from the intro-ether world, the urelement of Dr. Jencken, and the cosmic worlds; and the eccentric action (a pouring forth into space, or peripheral expansion)—creating light; and a reflux from the peripheral back to the solar central, creating the forces designated as gravitation, attraction. Concomitantly with each state, and antecedent and sequential to this, the intro finer ether states exist—each prior state so constituted that it can permeate the former without interference, and act dynamically, that is, creatively, as an originating cause to the less finer materiality. From this follows, that the finer ether element, which really sustains and impels the onward motion of light, is not interfered with by the next wave of power emanating from the solar centre—it coexists. I infer, therefore, that each ether wave of power, as it pours forth from the sun, possesses an inner finer element, which coexists in space with the other wave undulations of solar forces; hence an endless number of these peripherals coexist in space, sustained by the central body itself.

Another law operates here, and I may be further allowed to deal with it. Admitting that central points and their peripherals exist, where is the space that holds them? I repeat, they coexist in space—each is so distinctive in its nature, that coexistence in space is possible. Coexistence of peripheries is a term I venture to use to explain my meaning. I will not trench upon metaphysical ground,

nor repeat, with Leibnitz, that each monad encompasses the universe, or, in other words, its peripheral is in the infinite; but I do go to the extent of asserting that co-existence of peripheries and the intro-coexistence of worlds within worlds, are fundamental laws of nature.

The peripheral expansion of light is an essential attribute of the act of change from one state of elementary condition to another. I am alluding to the primary elementary condition of each state, intro primary ether state, to the next ether state, and material concentration of the ponderable light-indexed world which we inhabit.

The polaric character of light Dr. Jencken has fully developed in his treatise, 1852. The dualism which it carries from its very first creation characterises all the varied phases of its existence, in the coloured transition forms we witness in the spectrum, and its other manifestation. The spectro analysis would lead to far more important results, if, instead of seeking a parallelism between the materials of our globe and that of the sun and of stellar bodies, the phenomena were studied as a guide to the comprehension of the negative and positive states of light, representing the dual action, and the transition forms of light in their polaric unfoldment. The flame of the burner, the artificial flame, and the solar ray, are to one another as negative and positive—the latter is the light of a primary creative formation, the flame of the former is that of the act of resolution. Sun rays do not destroy artificial light because it is less bright; but they *kill* the candle light, because of its opposite negative character. The fact of the similitude of the spectrum of a candle flame and of solar ray, proves only that the dynamical states of the material, in its creation and in its resolution, are the same, and are invariably accompanied by a condition of transition we designate as light, heat, electricity, &c. The bright lines in the spectrum,

produced by incandescence of minute particles of metal in the burner, and which resist the solar agency—that is, do not become dark—for instance, gold, silver, lithium, &c.—these, I contend, do not establish the fact of the non-presence of these substances on the surface of the sun, no more than the darkened lines or bars prove the presence of given substances; but on the contrary, this highly interesting fact only confirms the negative and positive character of light, and its ready susceptibility to the action of substances, as they range themselves to the one side or the other of their respective poles. The dualism light carries with it from its earliest creation pervades our telluric system, for our earth is sun-created. Solar rays, solar power, and their products, permeate the earth's crust; and even the nobler metals, as they become consumed in the oxygen of the flame, yield to the influence of solar power, become oxydised. Metals themselves become permeated by light.

The solar spectrum, examined by coloured glasses, presents a marked similarity to the spectrum of certain bodies in an incandescent state: for instance, pure hydrogen shows a blue flame, and with many of the rays of light wanting; that of an oil lamp contains most of the rays which are absent in sunlight.

Herschel's theory is too well known to need more than an allusion. His theory is, that the rays wanting have been absorbed by the sun's atmosphere, presupposing a state of things on the sun's surface I cannot admit—namely, an incandescence of the nucleus and vapour clouds surrounding the solar body, composed of the volatilised vapour of metals. But planets and fixed stars equally show the bands or dark lines: for instance, *Venus* contains DF 6 and F of Frauenhofer's tables, similar in position to those created by sunlight; *Sirius* gives only strongly marked bands in the *green*, and two in *blue;* in *Pollux* the weak

but fixed lines were like those of *Venus;* and the star *Castor* gave results exactly like *Sirius.* In the spectrum of the electric light there are a great number of bright lines; but the ordinary light of a lamp "*contains none of the dark fixed lines,*"* though *orange* is present. The spectrum from the light of a flame maintained by the blow-pipe, contains several distinct bright lines. In the 600 bands in the spectrum field, the maximum illuminating power is never to the red extremity.

Kirchhoff and Bunsen, and Huggins of the present day, countenanced by a host of physicists, infer (as already stated) from the changes in the spectrum that the bands undergo, that substances exist, or do not exist, on the solar body, according to the index given by these dark or luminous bands.

I repeat that the inference is wrong; that the change in the condition of the lines or bands of the spectrum, point to a variation of the polaric condition of light; that light in its very inception at the solar centres (or produced by incandescence) obeys the same laws of polaric unfoldment wherever it exists.

The views of Brewster—that red, blue, and yellow represent the primary colours; that on the boundary line of each of the coloured fields of the spectrum, their presence is observable; and that the other colours are products of the dual action of these primary colours—carries us a step onward to the theory I am advocating. Colour is but the product of the negative and positive in the ray of light polarically unfolding itself the instant a check occurs; a change, any act that furthers transition from the first point of the primitive and intense centralisation at the primary luminous centre itself, until the final transition

* Brewster's Optics.

into a correlate of light—heat, electricity, &c. Each change is marked by an alteration in the condition of the polaric expansion; by a left and right divergence of polarised light; by the coloured fringes that accompany the wonderful intricate course of once polarised beams; by the prism colours on refraction, the iridescence of bodies generally; by the absorption of light, one of the most remarkable of its properties. The dualism of light is manifested in double refracted rays. The dark lines of the solar spectrum only denote, as Dr. Jencken has justly pointed out, the recoil of light upon itself, before expanding into a farther advanced, farther extended, polaric unfoldment. Each colour on the spectrum field is again central, with its left and right, negative and positive, and defines its boundary lines in the non-light existing state. Herschel's theory of the absorption of rays in the sun's photosphere, is too uncertain; pre-supposes a state of matter on the sun we have no proof of—a perpetual incandescence. I have already alluded to the light of primary formative creative process, the centralising of the ether influx into light at the heliotrode; and have also stated my views of the light of resolution, decentralisation of matter —that the solar ray, and the beam of light from a burner, are opposite in their natures, but certainly not complementary to one another. The complementary phase of positive solar light is in the negative of solar light itself. It is this error that is leading the inquiry of the present day into the nature of light, by the aid of the spectroscope, on to quicksands, conducting to conclusions that cannot be accepted. The strict analogy between the phenomena of the solar spectrum and the spectrum of other light, I cannot admit.

But I must refrain from entering upon controversial ground: my space will not warrant this. It may not, however, be out of place to state my objection to the theories

of Kirchhoff and Bunsen, and the school they have founded. Possibly, at some future time, I may re-open these pages, and give the result of my researches into the nature of light and the spectro analysis, based upon the principles I have rendered, accepting the theories of Dr. Jencken as the foundation I intend to build upon.

But before quitting this subject, and one that I admit has thoroughly roused the whole interest of my mind, a few words upon the dynamic properties of light, and the correlates, to use the term employed by Grove in his excellent and learned treatise, "Correlation and Continuity," 1867.

To confine light to its radiant character, and refuse to extend our inquiry beyond, would be committing a grave error—one which, however, even Whewell, with all his power, made himself guilty of. The radiant visible property of light the undulatory theory explains; but the other properties of light—its chemical effects, the optical *polarity* of a crystal and its connection with the polaric condition of its constituents, the diffraction, inflection, interferences, the oxydisation of surfaces as the cause of natural colours, the presence of chemical action of light, the presence of heat, electricity, magnetism—the undulatory theory does not explain; and yet light produces all these phenomena, it vitalises, and the organic action of light is witnessed in the fauna and flora around. These facts speak to us in unmistakable language: they tell us that solar light, solar power, is not a material, one-sided phase of matter, a mere mechanical radiant force propelled into space; but, on the contrary, one of the many forms of transition the intro-ether wave undergoes, as it becomes transmuted by solar concentric action, transformed into light, and thenceforth passing onward, changed into the so termed primary dynamical elements of this ponderable world,

and from these into gases and water, rock and plant, and the organisms of animals. Each transition is accompanied by the phenomenon of some one of the dynamic physical forces—of light, heat, electricity, chemical affinity; and at each step of the metamorphosis the law prevails, that the greater the change, the mightier the resolution back into the primary elementary state—which I designate as the primary ether state—the more intense the action of these forces and the dynamic physical forces. This resolution, and the reconcentration that follows, produce light, heat, and the other correlates, not as latent properties in matter itself, but as exponents of the conditions through which matter passes from one state to another state. And with these remarks I will conclude.

I have only rendered this essay as a prelude to the treatises of Dr. Jencken, and with no intention of writing one myself, my object being to give to those treatises an historical background in the form of an introduction. If I have ventured to add my own views, I have done so with diffidence; nor should I have had the courage to state them in direct denial of the many theories great men have propounded in endeavouring to understand the laws of light, but for the high order of interest of the subject, which has encouraged me to think for myself, and utter what I have thought. Light—this most potent, least understood, ever present, and never grasped, phenomenon of nature—above all deserves our earnest, thoughtful consideration; and my hope is, my trust is, that its study will lead to a profounder understanding of the laws of nature.

NOTE—Page 72.

TREATISE ON THE EYE.

THE subjective action of the eye itself, the very formation of the organ of vision, with its wonderful adaptation to the use for which it is intended, presents matter of such high order of interest, that I may be allowed to devote some short space to the delineation of the anatomical structure of the eye, and the recording of the opinions of those who have studied the important question of the function of vision.

The eye has been justly compared to a magic lantern—the imagery of the outer field of view being refracted and reflected upon the retina, but inverted, as may be ocularly demonstrated by taking the eye of an ox, and pairing away with a sharp instrument the sclerotic coat. The eyeball rests in the bony cavity of the head; the orbital hollow is covered anteriorly by a fine, highly sensitive, mucous membrane, the conjunctiva; underlying this, and enclosing the whole of the eye, except the place occupied by the cornea, is the *sclerotic tunic*, a firm, fibrous membrane, white on its surface, and to which the white of the eye is owing. Resting in front, and attached by bevelled edges, is the *cornea*, in its form not unlike a watch glass. Immediately behind the *cornea*, are the *iris* and *pupil*, the former so called from the various colours it assumes in different individuals. The *iris* forms a wall, or partition (a septum), pierced by a round aperture; the *pupil* possessing the extraordinary sensitiveness to light, which causes the dilatation and contraction, one of the great safeguards against too sudden an inroad of light. By its periphery, the *iris* is connected with the *ciliary ligaments*, and, by the inner rim, the pupillar margin is formed. The *anterior layer* is *muscular*, with radiating fibres, by the aid of which the

pupil is contracted and dilated. The posterior layer is of a deep purplish tint, and from this fact called the "*uva.*"

Both the *iris* and *pupil* are part of the *choroid* membrane, a vascular, rich brown membrane placed immediately on the sclerotica, and enclosing the inner wall of the eyeball. This membrane is again divided into three layers—the *venous, arterial,* and the *inner layer;* the latter composed of several laminæ of nucleated hexagonal cells, containing granules of *pigmentum nigrum.* Resting on the choroid membrane is the *retina.* But before I proceed to describe this organ and the optic nerve, it will be necessary to delineate the *crystalline lens* and *hyaloid membrane,* the latter containing the vitreous humour.

The *lens* is a crystalline body more convex in front than posteriorly, is composed of concentric layers, of which the external are soft, hardening concentrically, until, in the nucleus, they form a firm, hard "kernel." The concentric lamellæ are again composed of minute *parallel fibres.*

The lens itself contains the *liquor morgagni,* and is situated behind the cornea, and connected by fine ligamentary fibres with the choroid membrane and the ciliary processes. Posteriorly to the lens, and filling the entire space of the eyeball, is the *vitreous humour,* enclosed in the extremely delicate membrane, the *hyaloid,* which sends its processes into the interior of the vitreous body, forming *areolæ,* in which the vitreous humour is contained. I have omitted to mention the *aqueous humour* in front of the cornea, and which, according to M. Petit, scarcely exceeds four or five grains in weight. The eye is thus composed of three refracting bodies. These, according to Sir David Brewster, possess refraction in the following proportions :—

Aqueous Humour.	Crystalline Lens.			Vitreous Humour.
	Surface.	Centre.	Mean.	
1.336	1.3767	1.3990	1.3839	1.3394

But, as the rays refracted pass, firstly, through the aqueous humour, then into the crystalline lens, with its centre denser and darker than the outer layers, and, finally, into the vitreous humour, the indices of refraction will be, as regards their separating surfaces, as follows :—

From the aqueous humour to outer coat of the crystalline lens, ...	1.0466
From this to the crystalline, mean index, ...	1.0353
From vitreous to crystalline, outer coat, ...	1.0445
From vitreous to crystalline, using mean index, ...	1.0332

Posterior to the lens—and which is delicately suspended by the *ciliary processes* attaching to every part of the margin of the bag or capsule of the lens—is the *vitreous humour,* which the *hyaloid* membrane holds within its folds, and which constitutes, as I have said, the great bulk of the eye, filling the whole of the cavity between the lens and the concave wall of the posterior surface of the eyeball.

Resting upon the sclerotic coat, and forming the envelope of the whole eyeball, is the *choroid* membrane, of a rich chocolate brown colour externally, and black interiorly. The *areolar tissue* connects it with the sclerotica, accompanied by nerves and vessels. As already described, the *iris* and the *ciliary processes* are only a continuation of this dark vascular membrane.

The *retina* rests immediately upon the choroid membrane, expanding like a net, and occupying nearly two-thirds of the distance between the foramen of the optic nerve and the centre of the eye. This nervous membrane, or *third tunic,* is again composed of three membranes—the *external* or *Jacob's membrane,* the *middle* or *nervous,* and the *internal* or *vascular membrane.* The nervous membrane is of a semi-transparent bluish colour, and envelops the vitreous body, terminating at the ciliary process.

I have now only to describe the *optic nerve,* or the "second pair of nerves," arising from the *corpora geniculata;* and, in passing through the optic foramen, this nerve receives a sheath from the *dura mater,* which loses itself in the sclerotic coat, and, after a short course, expands into the nervous membrane, the *retina.* The innermost fibres cross one another to pass to opposite sides—that is, left nerve fibre to right, and *vice versa;* whilst the outer fibres continue their course uninterruptedly through the optic foramen. The description of the anatomy of the eye has been rendered with a distinct motive. The mere study of

the parts of the eye will demonstrate that it is essentially lamellous, is composed of layers, repeated in every part. The cornea, lens, and retina, are all formed of thin layers bound together. The eye is thus the representative of the reproductive *(Dr. Jencken)* pole of the human organism. The whole of the organ of vision tends to show that it is peripheral, not central, in its structure. What use, then, has the repetitive form of membranes apart from their optical function—I mean, the concentration of the rays of light by refraction? The lamellæ perform the function of mediation. By the *iris, uva,* and choroid membranes, the refraction of the rays is mediated in such a manner as to direct them, mediated, to the retina; the optical act is accomplished by means of the cornea, crystalline, and vitreous humour of the eye.

The repetitive layers, the lamellous structures, produce a change in the concentrality of the ray of light itself, to the effect that, when the image (inverted, as may be easily seen in the eye of an ox) is reflected upon the retina, it shall be sufficiently changed, loosened, decentralised, to adapt it for assimilation by the inner organ. The optic nerve does not convey the direct image to the brain: this the experiments of M. Mariotte have proved. The base of the optic nerve, or the circular section immediately at the entrance of the optic nerve into the eyeball, is wholly incapable of conveying an impression to the brain. To prove this, it is only necessary to place three wafers, two feet apart, on a wall. By retiring gradually, one wafer will disappear; and *(Brewster's Optics, p.* 290*)* if the experiment be repeated with a candle, the same result will take place. M. Mariotte concluded from this, that where there was no choroid coat, no vision occurred; and, in the *sepia-loligo,* or cuttle-fish, an opaque membranous pigment is actually interposed between the *retina* and the *vitreous humour.* In young persons, Brewster says he has observed that the choroid, usually supposed to be black, reflects a crimson light. Now, if the *retina* was affected by light transmitted through it, objects ought to appear tinged: this they do not. M. Lehot actually supposes that the image of vision is formed in the vitreous humour; and

he argues with considerable force that we see an object with *three sides*, whilst, were the eye a mere optical reflecting instrument, the objects ought to appear flat. This seeing an object flat, often accompanies the first symptoms of *cataract*.

The disturbances of vision in disease, indeed, furnishes an excellent guide to the understanding of the right function of the eye—perhaps the only method available for us to determine its operation—when, as Daniel Bernoulli tells us, one-seventh of the part occupied by the nerve filaments (the optic nerve part) is unimpressible to light. Sir David Brewster, with true philosophical acumen, says: "As difficulties still attach to every opinion respecting the seat of vision, we shall adhere to the usual expression used by all *optical* writers, viz., that the images of objects are painted on the retina."

With no sure guide to conduct us, the question arises—where to look for some certainty in solving the all-important problem of the functions of the eye itself in seeing. Step by step, as the inquiry is pushed farther back, other mysteries present themselves. The laws of *visible direction* show that the *centre of visible direction* is at one given point—the eye being as near as possible a sphere, because every point of the object seen is "in the direction of a line drawn from this centre to the visible point." Here I have, then, an organic centralisation of the impinging rays, and, from this point, a dispersion, a severance; the image becomes changed by the refracting medium of the vitreous humour, and, finally, appears inverted on the surface of the retina. Why inverted? The upside down is not permanent. Close the eye, and the object will still be seen in its *upright* position. Though the image seen by closed eyes is only complementary to the positive primitive impression, yet the form and position remain. Mark the law that has to be studied: the optic nerves—the inner fibres—cross from left to right, from right to left, on the very threshold of their ingress into the eyeball; the image is inverted on the retina; the optic nerve insensible to the action of light; the retina, beyond doubt, not the seat of vision. As to ascribing to a mere

vascular tissue and carbonised pigment, the choroid, the power of sight, such theory can scarcely be sustained.

The laws of *distinct vision* aid us in following the inquiry. *Oblique* or *indistinct* vision is inferior to direct vision, but it, nevertheless, exists; and the transition from the maximum power of direct vision to the uttermost dimness is gradual, proving that the visual impression is not confined to one central part of the retina (even admitting that the retina actually sees, which I deny). Sir James South and Herschel have shown that the less the power of indirect vision, the keener it becomes: by a side glance the smaller stars are visible, which by direct impression could not be discerned.

The cause of single vision by two eyes results from the law of visible direction—that is, the axis of each eye can be so directed as to point to one given centre in space, four to six inches distant, and more, from the eye; or, in other words, the centralisation which intimately takes place in the inner organ must be objectively faultless, produced upon one axis of direction.

But here I have not done. How, I ask, is the act of *accommodating the eye to distance effected?*—a function repeated at every moment, as we look at near or distant objects. Brewster thinks that the adjustment depends upon the contraction and dilatation of the pupils, the lens being, in fact, brought forward and withdrawn by these means. (See *Edinburgh Journal of Science, No.* 1, *p.* 77.) The law appears to me different. The extreme polaric points, the top and bottom, the extent of the angle formed by the margin of the object seen and the centre of the eye, act excitingly and polarically upon the eye, but with a two-fold operation—that is, small objects in close proximity to the eye reflect the light with greater energy, and thus, apart from the polaric intensity of the angle of proximity, stimulate the retina (I use this word, though denying its action); whilst larger objects, with the light weakened by distance, though occupying the same space, have only a moderate stimulating effect.

A parallel instance presents itself in long-sightedness *(presbyopia)* and near-sightedness *(myopia)*; the eye, not

the lens, the organ itself, acts too concentratively, disturbs the inner focal point—that is, the image is formed before it is finally digested, mediated for the last act of *inward intro-vision;* or, as in presbyopia, the concentration is too imperfect to reform into the object an outline. These defects, unless accompanied by disease, may, as is well known, be easily remedied by the aid of glasses, which artificially change the focal points, concentrate or disperse the rays.

Next for consideration are the *Physiological* Colours—"*Coleurs Accidentelles*" of Buffon—the "Accidental Colours" to which Brewster devotes a whole chapter—the "*Subjectiven Farben*" of Goethe; and it is with undisguised pleasure I enter upon this field of my research. I feel as if at last I had entered the sacred building, and could see within the imagery of its painted windows.

The colours proper and the colours of the *ocular spectrum* range themselves in the following order. The harmonic colours—a term applied to accidental colours, because the primitive and accidental colours harmonise with each other in paintings, as in acoustics (Brewster, p. 309), "where every fundamental sound is actually accompanied by its harmonic sound." Accidental colours and primitive colours, having the same intensity, produce white light, a phenomenon of high significance; hence the term complementary colours. The explanation of Sir David Brewster is, that the red wafer (I am supposing the experiment to be carried on by placing wafers of different colours, under an ordinary light, upon a wall) deadens the action of the retina, and that light—impinging subsequent to removal of the first impression made by the red wafer, the primitive colour—is not received by the retina; and, for the same reason, a black wafer produces a white reaction, and *vice versa.*

Goëthe, in his "Farbenlehre," furnishes detailed accounts of a series of truly instructive experiments. I can only but notice them. He, too, (section 40, tom. i.) alludes to the vanishing of the colours after gazing at a bright spot in a dark room. First, he says, the action of the eye, whilst undergoing the influence of light, is not unlike the wave rings on a surface of water: the impression forces its

way eccentrically in rings, impelled from the centre, thrown back by the peripheral resistance—the colours changing from yellow to red, then to green, with a red rim. These are the subjective rings; but the reaction of the retina itself, after the exciting effect of a clear and strong light has passed, shows, first, the outline of the image seen. This can be verified by placing a luminous cross in the field of view: the spectrum changes from yellow to purple, then into blue, and finally the image narrows in outline, and ultimately disappears. The duration of these appearances depends upon the strength of the eye experimentalised upon. One constant law, however, regulates their presence, and which Brewster, as stated, designates these "harmonic colours,"—the "chromatische harmonie" of Goëthe: for instance, yellow produces the complementary colour of violet; orange, that of blue; purple, green, and *vice versa*. The green tinge of the ocean waves produces the purple colours often observed on the ocean surface; and many of the most beautiful coloured phenomena of nature are the resultants of the subjective acts of the eye itself. These subjective colours nearly cost Sir Isaac Newton his sight. He directed his right eye, having closed the left, to the image of the sun reflected from a mirror; thrice he repeated the experiment, and in a letter to Mr. Locke he communicated the result. He noticed the effect on the closed eye, which, to his surprise, equally saw the spectrum. Sir Isaac Newton, in order to cure the injury his eyes sustained, had to shut himself up in a dark room for several days subsequently. This Lord King mentions in his life of Locke, where, in a letter of Newton to Locke, the account is given. ÆPINUS made similar experiments, and he describes the spectrum, on closing his eye, as of an irregular *sulphur yellow*, encircled with a faint red border on a white ground; on opening the eye, the sun's image appeared *brownish red*, with a *sky-blue* border; then, again, green upon closing his eye; then blue, with a red border. These experiments Sir David Brewster repeated with similar results. It would be fruitless to follow Mesmer, who mentions that he observed that a ray of sunlight, which passed through a red curtain, appeared *green*. Mr. Scott, Mr. R. Tucker, and Professor Hoek of Dorport, have fully

exhausted this subject, and I have now only to add a few remarks upon "*Pathological Colours.*" First, those remarkable cases of inability to distinguish colours: certain eyes cannot see red, others cannot distinguish green. This defect of the sight has been termed "*Akyanoblepsy.*" There is another form of diseased action, consequent to an injury: a blow on the ball of the eye produces colours, sparks, and inflammation of the organ; the flame points, flashes, and indirect circles, noticed by patients, point to a subjective power of the eye of producing light itself. In operations for cataract, the flashes and coloured rings continue to be observed by the patient for fourteen days, and even longer, after the operation; and in *amaurosis*, the flashes of light, or floating black spots (the *muscæ volitantes* of the ocular spectrum of patients); the *diplopia*, the objects being doubled; or *hemiopia* (only half seen), the flame of a candle appearing generally split, lengthened, and broken into an iridescent halo—all this denotes a disturbed image on the nerve aura. The choroid membrane, without a fibre of nerve filament, when attacked by disease, produces similar symptoms, with intolerance of light and dimness of vision. But I have no intention of diverging into a medical treatise; my only object has been to state such facts as will warrant the theory I am now venturing to render.

All are agreed—philosophers and physicists—that the right understanding of the final function of the eye, the last act of seeing, is not understood; and Sir David Brewster allows that the expression, "action of the retina," must be only conventionally employed; its true function we know nothing of, and do not understand in the least. Now, what is this function?—how is the inverted image of the object we see reflected from the retina placed upright?—and how is the coloured property given to the object, so that the brain may recognise it? Here I suggest a theory, which I am compelled to accept until something better presents itself. The retina, I conceive, does not perform the function of vision, of receiving the wave undulations of light, and, by contact, communicating the vibrations to the brain through means of the conduct pipe, the optic nerve; but the retina, as indicated in its very

function—lining, as it does, the inner wall of a globe of the eye—focalises the nerve power of the brain, meeting the influx of light in the vitreous humour;* and the action that is conveyed by the optic nerve to the brain, represents this mediated influx of light, the double product of the nerve power, and the inciting ray of light. The image, however, which the brain finally sees, is not the inverted object reflected on the surface of the retina, but its polaric representative, *the complementary pole only is seen;* hence the inverted position of the object becomes necessary to the act of seeing; for we only ultimately see the *polaric reaction,* and top and bottom represent the poles of an object, the opposite extremes. I carry this reasoning a step farther, and maintain that the colours finally seen are only the complementary colours on the retina (I use this term retina conventionally): I mean, that the inverted image, and such colours as it possesses, are not those of the objects seen, but their complementary colours, and which reproduce on the brain the reaction, resulting in a reaction of the complementary colours, and the production of the actually seen objective colour on the brain itself; hence the function of the retina observed by Newton, Goëthe, Æpinus, Hoek, and those who have studied the question. The reaction of colours on the retina, the inverted position of the object, only point to the ultimate "digestion," assimilation, *mediation,* by the law of polarity, of the object seen. To see it becomes essentially necessary, that the image primarily formed in the eye itself should represent the polarically-formed impress upon the *nerve aura* of the eye—and this outer nerve aura then reimpresses the image so formed upon the inner, finer brain—ether element. In the convolutions of the *thalami optici,* and the *corpora geniculata,* the eye produces a negative so as to impress a positive, enduring image on the inner organ of vision of the brain itself.

This law of reaction has been recognised by Hahnemann. The lasting effect of a medicine was not to him

* M. Lehot conceives that the image was formed in the vitreous humour; for he says, with great reason on his side, that we do not see the image flat, but with width, breadth, and depth.

the symptom, but the reaction; hence his rule, "*Similia similibus curantur.*" I mention his theory in support of my own; for I maintain that, to produce the act of seeing, the polaric extremes, both in the inverted position of objects seen, and in their complemental colours, must function; the object seen is a middle product of the two poles represented by the brain aura and the physical outward light, acting upon the aura of the retina. The great law of dualism, that bound light together in the heliotrodal point, as the wave influx from the ether world pulsated into existence—this law holds good throughout the paths of light; and meet it where we may, we can but know of its existence by the presence of both its poles imaged, as is the case, upon the retina, as action and reaction, as a negative producing a positive impress. Every part of the eye aids in this process, and the endless laminæ of the cornea, lens, and vitreous body, break, untie, nay, polarise light, fitting it for the ultimate polarisation in the production of a negative image on the inner wall of the eye itself.

The subject matter I have touched upon is so vast, I dare not proceed, or I should be filling a volume; but so far as I have gone, the data given are essential to the study of the laws of light. The eye sees, and all the mathematical rules in the world have hitherto failed to tell us how. I repeat, the eye sees by forming a negative in the complemental colours, which again produce the lasting effect, the true image seen. The whole function of the eye is towards this end—namely, to produce a negative. Now, this negative is taken from the ray of light itself, and impressed upon the nerve aura of the eye, which has been focalised by the retina, and thrown upon the inverted image; this inverted image, with complemental colours, is then impressed on the inner organ of vision in the brain, and produces the permanent lasting effect—the righted figure and true objective colours we actually see. I have re-stated this, so that my views may not be misunderstood, though at the risk of repetition.

TRANSLATIONS

OF

DR. JENCKEN'S TREATISES

ON

LIGHT AND COLOUR.

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TREATISE

ON

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PUBLISHED UNDER THE TITLE OF "MY HOBBY," 1837.

THE theory of undulations most nearly approaches the truth. A primary elementary force, composed of solar elementary, cosmic elementary forces, and created by their united action, forms the continually supplying, nourishing influx of primary elements, which sustain the physical world and its products. This oscillating ether, which physicists accept as the common element, is but the manifestation of the influx of all these forces of the stellar worlds, of suns and earths, from which the other forms of the physical world are evolved. No one denies that the sun and planets have an influence on this earth. Where, then, does the continual influx of force remain, unless it be consumed? and how can all the products of nature, in this never-ending change and mutation, be sustained, unless supported by renewed influx of the solaric cosmic elements?

It is true, all space is filled with this primary ether, which again is only the first investure and manifestation of a finer power; and this force or power resulted from

manifold union, concentration of the forces of suns and planets, their combination, action, and reaction, and influence of more distant suns.

Thus, this primary ether is in itself a general vital power; for vital force means the union of several agencies to effect one common function, an eccentric action arising from the central combining power. The primary ether pervades everything—air and water, minerals and organic life; but the concentral repletion is transformed into individual production, consolidates, and again resolves itself, streams onward, and in this act draws with it the ever-supplying influx; and this influx is always present, but only in the primary ether form, in the primary manifestation of a force. This primary force passes into the nearest onward, possibly into the form of light, carrying with it, as it progresses, the influx of the more primary, less assimilated ether stream. Hence one point of progress conditions all the others that are connected with it; and this explains why the consumption of one atom of solar force on the earth, changes the next to the form of light, and thus onward to the sun itself. The efflux of force from the sun is, however, not in the form of light, but of a power more subtile still; for there exist ether elements yet more primary, finer, and finer still. Light is only created by the act of increased planetary resistance, which this influx from the sun meets as it enters within the range of the telluric influence, and heat and air form themselves out of this.

Light is, therefore, not an eccentric radiation of an emitted force; but, on the contrary, an incited axis of direction of points changed along its course, and which we recognise as a ray of light—a lighting-up in thousand upon thousand successive points of ignition. The resistance experienced in the last point of contact, induces accumula-

tion in all, and transmutation resulting from this. But increase of supply at the first point causes a super-influx of the higher primary force or power, in addition to the greater adaptability of the force for change, and induces the tendency to remain stationary in the primary element, an apparent check or retrogression; the positive tendency becomes dominant in regard to the negative, the formative act lessened. Each point mediates the other, and where in any one the formative process is hindered, this reacts upon all the others: transition from one point to another, in swiftest succession, constitutes the essence of its existence. In the first mediatory transition from point to point, the onward tendency predominates; and onward from the second to the third, and continually unto the last —not necessarily the highest incitive power, but only the otherwise excited state of the first point, and onward from that; for in all the same primary element is present, and in fullest, amplest supply, with power of direction towards any given point. This undulation might be compared to the ripple of the last and farthermost wave: it is a continuous transmitted impulse, but without the first wave-crest ever reaching to the last undulation.

Every luminous body emits the primary ether element in the form of light. But an absolutely non-luminous body cannot exist; for the primary ether streams forth from all to all, conditioned by its proper action, and the resistance from without, to accept a creative state—a state mediated by antecedent grades, through which again and again it passes. When, however, as is the case at night, the solaric influx is diminished, then the negative stagnatory tendency becomes dominant, which again causes a stagnation from without, causing possibly a telluric light (aurora borealis). Darkness, too, must have its dark rays, as exponents of the negative phase of light, where the

transmutation of the inner finer ether element is more rapid than its influx.

Light and shade are primary equally invisible, and according to Goëthe, becomes so only in and by the transition to colour. Light is a form of transition of a power: every visible light is coloured. Light is a state of power, and of that primary formative condition arising out of the planetary cosmic elements, marked by the least amount of stagnation, specifically determined by contact with each body impinged upon; hence the difference (such as our sense of touch can only understand) to the eye, this most sensitive organ for the appreciation of the presence of this elementary influx of primary force. What the ear is for the influx of vibrations conveyed by the air, the sense of touch is for the all-pervading primary ether influx. The nerves and their terminal filaments receive only the *elementary efflux* from bodies; these effluxes carry their impress of each individual substance. From our nerves, this influx passes onward, which, as an elementary force once combined for the use of our organism, passes again with the great stream of ether elements, and attracted and influenced by these, even in the very act of onward streaming. Our senses mediate the external elements with far less stagnation and difficulty than the coarser inferior organs, because the onward stream, the withdrawal and passing on occurs more rapidly (greater union of organic powers, more speedy assimilation). But the two streams must unite—the stream from the senses, and that from the inner finer organs of our inner conciousness, and the nerves that supply these.

Hence, in dreams forms are seen, images and light. In sleep the elementary influx from our coarser organs predominates, obscured and deficient in combination and harmony, obstructing more defined perception, and impeding

clearer consciousness. In dreams the imagery is outlined in distinctive forms, but without the higher combinatory power of superior unity. During the waking state the stream passes from without through the senses, which offer greater resistance, and possess greater power of combination, thus preparing a higher point of contact for the mind; and here, then, a more compact, intense union of the manifold elementary powers and influxes is established before they travel onward, a more perfect wave of existence; and thus the formation is purer, more harmonised, more enlightened, freer, and more perfect in shape and appearance.

The ray of light is not a sudden pouring forth of an efflux of power in a given direction, but a sudden excitement of the already existing points of power into the transition state of light, followed by never-ceasing influx. The ray of light appears in a given line of direction, because it is composed of a succession of moments or points, each mediating the other.

Contrary forces develop themselves laterally on every occasion of impulse of force, for laterally too the excitement prevails; hence light is divided into rays, transformed into such, from what at its inception must have been in layers or strata. These rays carry between each other, and laterally, the limiting opposition of lateral action, whilst onward the mediating process of the nearest moments. All states of force (physical dynamic), light, heat, magnetism, and electricity, must move in rays, *mutations arising in continuous points of contact;* and each moment is distinguished by the opposition above and below, and each ray limited by the opposition laterally, and hence individualised, bounded by confines of its own. Resistance, ever-present resistance, opposition, fashions each power into moments, ultimate points, *momente.*

Arrest, retraction, and expulsion, stand related to each

other, as manifoldness and unity, as periphery and centre: from these a finite manifoldness is generated. Negative and positive are identical in the circle—a positive and negative striving with equal extension and retraction must coexist, which the diameter formed by the radii indicates, and forthwith separation is produced. The twofold and the multifold arise from unity, and the subdivision proceeds to infinite, yet marked by the ideal point of the "finite in the infinite," and the onward course subdivided into infinite numbers of points or moments, but with a finite and marked limit. The rules of the finite applied to the infinite, such as the differential calculus, gives finite law in an infinite circle.

The instantaneous excitation of all the moments into a state of transition, consequent upon the influx at one point, will explain the swiftness of the transmission of light, as also that of sound emanating from the vibrations of a string. Heat, however, and the wave of sound through the air, has less velocity, on account of a diminished power of transition in the moments themselves.

Newton's theory of the division of a ray of sunlight, has been fully refuted by the master-mind of Goëthe. Wherever power, force, and matter, are conceived as severed, this final division doctrine may be accepted, and the composition of a ray of light of coloured rays forming the white, purer beam of light admitted. But where the material is conceived, as a state of power there, a transmutation, not division and splitting-up, gives the law of phenomenal creation. Matter is constantly re-created, is a becoming to be, not a constant permanent in a given form, composed of many atoms. Goëthe explains indisputably how light and shade are the polaric conditions of colour. A white surface upon a black ground, and a dark sheet upon a white ground, show coloured edges on inspection, and that in an

inverted order of arrangement; and the prismatic colours, the image of the sun, are formed by light and shade. In a darkened chamber, the incidental rays are changed on entering the dark space. But there cannot be an ultimate division of a ray, for no ultimate final beam of light exists; the most subtile is still composed of an infinite number of pencils of light.

Motion is always present in all the points of a ray of power; but the transition to this or that elementary form dominates, and the transmitted change from the point of first departure to the ultimate point takes place more speedily. In a jet of water, the inflowing stream arrives more tardily than the effect of the inflow at the end stream of water.

Transparent bodies bear to light the same relation as metals do to electricity—they conduct the light. In these bodies, the supplying nourishing element prevails and tends to the production of light, whilst in opaque bodies other tendencies are determinative. In the most ideal ether, as also in air and water, all the moments are too replete with the supplying influx of light, and are transformed too rapidly by the supplying stream into light, to cause a given direction being sustained by the incident ray of light.

Accumulation signifies the combination of two moments into one—that which required two moments of time, is now performed in one. The incident ray, with its primary resistance laterally, concentrates its action onwards, creates duality as the polaric product, the onward striving combined with a retentive opposition within itself, and can immediately be called forth as a dark ray. Every external opposition combines itself with this internal opposition, creating a negative, and calling forth the second direction in different degrees, and causing also the change of direction in refraction.

In transparent bodies, the formative tendency of the inherent points of light stands opposed to the acceleration of the new ray of light as it enters the transparent substance. Accumulation follows retardation, though possibly in the least conceivable degree. The other entering points all in succession participate in this; a different polaric relation ensues; the direction is altered. Direction signifies a striving forth from an inward opposition, creating a duality, polarity; change in the resistance necessarily resulting from this—change of polarity, and in the direction of its striving. But this contra-action affects only the line of direction of light, scarcely affects its transition, scarcely producing colour or shade.

Attraction is a change in the direction of the striving, produced by contra-action. The external stream joins the influx in the contrary direction; hence the attraction and absorption of this influx.

The true cause of all obscurity in the ray of light is its own inward opposition. When the negative pole becomes dominant, the transition is more thoroughly conditioned; hence a different elementary form from light, be it warmth, air, or the like; for that other forms of force are evolved out of light, is proved by the fact, that the red rays oxydise, and the violet beams of light carry warmth; this the transition of sunlight to oxygen in plants, the colorisation of blood and leaves, red and green, by the action of light, undeniably prove. In a vacuum the action of strong solar light creates oxygen, though in a very minute degree; light deepens the colour of all oxides; crystals are formed under the influence of solar light; flowers turn to the sun, and the perfume and taste of flowers and fruit are created by the effect of the sun.

The eye is the plastic organ: that which our sense of touch and the general susceptibility of the body performs

—namely, rendering a consciousness of the external possible to these—the eye, as the highest potensated organ for sensuous impressions, as the acme of the touch system of our nervous fabric, does of itself. The eye, like all the organs of sense, only receives what is in an elementary condition, in a state of striving and resolution (not what is stagnant), and only then when opposite conditions are resolved into an onward striving, and consequently constitute the minimum corporeal quality.

The eye, however, true to its plastic nature, only takes cognizance of what is plastic, and thus receives the elementary influx only in its plastic character. From this we conclude the presence of the contractive and plastic nature of every state of light, which is again only a state of power. The oxydising property of light confirms this view; and the next transition of heat to warmth stands in the relation of expansion from the previous concentration of the primary elementary influx.

Light is the initiative act of all plasticity in nature. The very form of light, in rays, points to a concentration; the pencil of light is but a bundle of concentrated primary elementary forces. Expansion must be impressed upon the very character of light, as the inherent reaction and opposite pole; hence the transition to warmth. But this action and reaction, true to the alternate character of the polarically opposed, follow each other as contraction and expansion. The first act of expansion is equally on all sides. Contraction is first caused by an opposition from without, the presence of a body it comes into contact with; thus the earth operates against the effluent solar power; the opposing force joins the negative pole of the outflowing sun power—wave accumulation becomes contraction; hence expansion and contraction are sequential to each other in the continuous formative action of forces. What-

ever adds to the negative force in light obscures it, nay, even extinguishes it, partly by producing a further change, transition, partly also, though seldomer, because the primary elementary influx becomes arrested, not transformed into light. The tendency to form colour is the inward polaric transmutative act; the sudden extinguishment by polaric opposition, as is the case in the operation of unequally long rays, or in polarised rays, deflection, reflection (possibly in the shadow of bodies), the other state or pole predominates.

Rays of equal length—for instance red rays—combine to form purer, intenser light, even where one is longer, but equally so; but where the difference is represented in fractions, such as $1\frac{1}{2}$ and $1\frac{1}{3}$, &c., here the point of juncture becomes dark, the supply is wanting, the nourishing influx, the $\frac{1}{3}$ or $\frac{1}{4}$ fraction, is defective in its supply, affords too little nourishment for the whole; retro-transformation ensues, possibly with a tendency to a magnetic elementary character (we will thus designate the general primary elementary force), the elementary plastic phase is broken, shade and darkness follow; but where the supplying element was in full strength, such as occurs in the momentary check sustained in the prism, causing accumulation, there the telluric influx negatively offers greater opposition, and the resolution, the newly created, expands self-existing, with a greater telluric character, yet, nevertheless, in an elementary form; colours appear as polarically obscured light, as proof of light rendered more material, light wedded to the planetary material; colours form the bow of peace upon darkly cloudy ground, symbolical of the combination of the higher life with the inferior.

Wherever the elementary cosmic supply accumulates for farther development, and retains its plastic condition of light, together with the onward transition, as in air and

water, in these instances we observe light penetrative, the body is transparent. But, on the contrary, as is the case in the shade of bodies where the sun power enters but slowly, the telluric power dominates, as in the cosmic at the opposite side; this combines with the negative pole of the weak or solar ray. No solaric force accumulates, only telluric; a repression, a repulsion of the solar is effected, and followed by shade and darkness. The solaric power either cannot transform itself fully into light, or the transition of the inferior influx of supplying power is too rapid, and passes on at once into other states of power.

In the first instance action is always negative, repellant; combination follows as a subsequent condition of supply. This is the case in the formation of light, which follows only upon the fuller influx of the solar elementary ether to the telluric; but, nevertheless, light even in an inferior degree is constantly forming everywhere; thus, too, magnetism, electricity, attraction, as manifestations of the state of power. Absolute darkness cannot exist, or light severed from shade, into which light penetrates as something apart. Light combines on the surface of every body with the telluric power set free there, and the polaric condition is further manifested at once as colour. Warmth, heat, is next produced; this the darker bodies especially initiate—they point to an advance in the transition that has taken place, with renewed incipient expansion, but marked by a telluric character, more material phase. Entering the body impinged upon, light passes into other states—heat follows colour; then air; and, finally, light becomes transformed by condensed waves into substance itself. Want of transparency is consequent to the transition occurring on the very surface itself; the next advance is that of a plastic character.

Colour is primarily the resultant of the action of positive

and negative light in the sphere of light itself; then followed by progressive production in nature. In hard transparent crystals the transition of light to colour does not take place on the surface, or only imperfectly; they are characterised by concentration, contraction; even the innermost lamellæ are contractive, and severed from one another; hence the readiness of fracture, vibration, increases this separation, repulsion, of parts. According to Haüc, compound crystals divide into primary forms, which construct manifold forms, the shapes into which they fashion; hence retain in the larger complex of the crystal itself the mutual character of repulsion, contraction. In semi-transparent bodies a more expansive element enters into combination—a basic principle (alkaline). Even the diamond readily suffers cleavage by an expert hand, and confirms the lamellar structure of crystals—the cone, pyramidal form, diminishing successively towards the apex, and indicating the primary type. Pyramids, like triangles, are formed by constantly increasing contraction from the broad base upwards (polaric contraction) towards the apex.

The ray of light is an elementary force in its primary plastic striving, and hence wherever contraction predominates, it experiences little assimilation. The reflection from the surface of a transparent body is very slight; the greater portion of the ray of light enters with the more powerful attraction which predominates in the crystalline force, nourishing it by the inflow of the general stream of assimilation. But light, even after it has entered, remains distinct from the other forces that coexist; an inward reflection follows (refraction); repulsion ensues where contraction meets contraction; the direction becomes changed; and this change of direction is conditioned in the primary elements that again supply it by the influx into this

direction. Action and reaction, manifested now as a change of direction, are undoubtedly the *primary* forms of every elementary force; and this manifestation of change of direction is maintained in all future transitions and transmutations, giving even to the repulsive poles themselves a connective direction. The more powerful the force of contraction in the crystal, the greater the attraction, the refraction, towards the perpendicular, the centre of the body in which it occurs. The feebler this refraction, the less central the action and the expansive character of light dominates, similarly to what occurs upon light entering a less dense medium.

In all schistose rocks (mica-schist slates), the crystallisation is less, deposit here becoming the primary product; but in granite, crystallisation predominated originally with an upward tendency, inward contractability, representative of the crystal formation. Where such precipitated mass acted upon the contractive action of the crystal, semi-transparency resulted. Light experiences there a transition into colour, for greater negative opposition combines with the negative contractive tendency of light, causing this transition. This is the case in all opaque bodies. The transition takes place on their very surface polarically, resulting from expansion and contraction, manifested as shade and colour.

The polished surface becomes more contractive by the polishing, is less furrowed, counteracts the change, and reflection occurs. All smooth surfaces, like the plated glass, cause reflection. The surface of glass induces a contractive tendency, and prevents light from being assimilated and transformed. Both contractions—that of light, and of the glass, or of the smooth surface—act and react upon one another, and stimulate one the other polarically, elementarily, and this where the primary elementary force

manifests itself in the character of a fixed direction of the physical world. The direction of the ray is changed. But here, too, the influx of sustaining forces continues: the polaric condition of direction is the combining of the negative to the pole on the positive side of the primary action of the pristine force. Change of direction is the consequence, though the production of light is the same. The influx of the primary ether occurs here also; the polaric determined direction is the consequence of the negative pole of the contra-action combining and becoming manifest in the positive action of this primary ether, and which again, in light, forms, so to say, a second, higher, primary, inward ether in the phenomenon of light. Light remains constant in its formation, but its direction is changed. The negative pole of direction gains equally as the positive loses. The greater the number of points of contact, the more perpendicular the ray impinges, the more will this change of polaric direction be developed, and this in alternate succession. The more oblique the impingement, the fewer of the above and external points touch the surface, and thus assume an opposite character; only the inferior and closely-placed rays come into contact, and these then mediate the influence of the opposition of the more superior ones, so that they, too, follow the direction of the inferior ray. Thus reflection is naught but change of direction of the inferior rays; and the opposition that produces this variation, coupled with the middle and superior onward course, and the outward, or superior—the greater this, the more obtuse the angle; the more the former, the acuter the angle—indexing the greater or less presence of the negative pole: hence the angle of incidence determines the angle of exidence, and the extremest opposite in the perpendicular ray, gives the measure, the boundary, the ultimate point the eye can mark.

This is the explanation of the law of reflection. In refraction, a more contractive character supervenes. Unlike the reflection from the mirror surface, higher contraction results. The direction is more marked, there is less commingling with collateral and laterally onward-speeding rays of light (atoms always vibrate laterally as opposed to the forward and onward—that is, the vibration is at a right angle to the plane of direction). In white surfaces, a lateral commingling takes place. Less contraction, as in the case of reflection, gives to all lateral rays power over one another, so that they alternate the direction. Light thus returns changed and intermingled in its direction, and more adapted for transformation and expansion.

The more moments of light accumulate at one given point, the more moments develop in the self-same period, the more intense the action. Colour is always the polaric transition of light into the more expansive character, conditioned by opposition of light, which necessarily first shows itself as shade. The eye itself even produces colour; hence the vision of the eye itself varies in different organisms. Pressure on the eye changes the effect of colour. The eye itself produces light, which emanates from the organic force set free in the eye; sparks and colours are seen with closed eyes; and the images in dreams are coloured, and contain their proper light, which pours forth from the organism, and forthwith forms into a plastic, light-carrying element, and the more so, when the sensuous functions and higher powers of the mind remain dormant (in the powers of our normal waking condition). A luminous point, the solar image itself, appears as a darkened spot on closing the eye; often coloured, and this because we recognise the organic force of light darkened in its primary transition, before, in fact, it becomes light; a negative action only, but without attaining to the positive

character of light; coloured also, as marking the transition act of light, even towards organic structure. The negative light (contractive in itself) is a dark ray. Here the supplying and resisting forces are both feeble; hence the ray of dark light remains as formerly (magnetic, cosmic), dark to the eye; or the retraction of light into its primary condition, produced the negative state, allied to its primary condition; and darkness, shade, consequent to a defective onward action of this force to the state of light, are produced, possibly consequent to a too rapid transition.

Light appears white through thick transparent substances, but emanates in coloured hues on passing through thin transparent plates of glass with parallel planes. Whence this change? Thus, the crystal causes a stronger contraction in the ray of light, whilst the thin transparent plate retards, but does not concentrate, and the beam of light, as it emanates, takes to colour, sustained by the opposite polaric force of the air itself. A plate of glass pressed upon a weak convex surface of a lens, and held up to the light, where pressed, shows a dark spot at the point of contact, with a coloured fringe. The slight pressure destroys, in the glass, the contractability; light is defracted laterally; the point of contact offers a resistance to the ingress of light; other forces become active, and light transforms itself at once into something else; polaric play of colour supervenes.

The dark bars that traverse the spectrum in and between the colours, seen in starlight, in electrical light, and the light of the ordinary candle flame, are only boundary waves, destined to manifest themselves according to the nature of each light. The opposition which conditions this transition into colour, as the line of demarcation between the negative and positive, not only manifests itself thus, but also in other forms of transmutation.

Effects condition each other by accumulation and discharge; the upward heave of the wave carries with it the reflux; the reflux, the upward heave. All supplying influx is divided into wave points, moments. Contra-action joins forthwith to the reflex action, and the farther contact is impeded; hence the latter joins with the reflex action, and the stream becomes divided into points or moments; the moments sever, the one is more impregnated with striving and reaction, the next less so, mediated by the former. This foremost moment is similarly placed to the next—a different relationship is formed there. In the beat of time, as in all mechanical movements, this is produced; cadence and the break in the stream flow of power indexed by this cadence, a withholding, an accumulation of power, resulting from this, caused by the resistance from without. The dark transverse lines are, so to speak, parallel to the division walls in the bar of the musical beat of time; they form the points of support for resistance, as the flame points that dart from point to point, show that progress has conquered, is ascendant. In the dark bars of light, the primary ether becomes dormant for a while, and negative light predominates.

Every form or state of power not manifested as light, but in a different manner, in a magnetic ether form, the cosmic, is recognisable by its character, not as light, but as darkness. It is true, no power, no force, manifests itself without some degree of light: absolute darkness does not exist; the plastic formative tendency of light is always present.

The eye, on closing the eyelids, even retains the impression from light and colour for a given time. The light influx has existed in the organ of vision, the function of producing light, and this action continues for a short period, even after the existing cause has ceased, vanishing ultimately into coloured hues; or as shade, representative

of the negative pole; or because the organic power enters into other functions, which absorb the elementary influx. The aberration of light, which gives to the starry heavens the semblance of an accumulation of stars in the direction of the axis of movement, has its cause in the continuance of the action of the impression on the organ of vision—a tarrying causing an accumulation, crowding together, of the objects seen, and resulting in an apparent intermingling and approximating of the objects seen; the eye cannot digest the impressions as rapidly as they arise.

Very remarkable is the fact that sunlight colours flowers, rendering leaflets green, and colouring other substances, and yet bleaching other substances—the withered leaf for instance. The physical, material action of light is evidenced by this very fact, if it were yet necessary to insist upon the irrefutable material power of light. Each force must manifest itself in some way; the form of appearance of power is its *materiality*. Light suffers resistance in the expansive element, in the telluric, carboniferous, hydrogenetic elements of the plant, and colour then indexes the transition; it is usually designated as a carbonising substance, but it is not this; the expansive property becomes consolidated, oxydisation produced out of light, and from this carbonic acid gas—the carbon representing the contractive pole of the telluric elements. Colours that are not sustained by the presence of the expansive organic forces, bleach in the light of the sun, as also by the action of oxygen. The very fact of white predominating proves the dominancy of the mineral contractive force; the expansive power is consumed, is lost in air; the other influx is more mineral in its character, more contractive, fixing the white light in permanent plasticity to itself, similar to all polished surfaces and transparent bodies.

A pane of glass shows coloured patches, after being

exposed to sunlight for some time. This proves that here, too, a gradual combination takes place—the expansive pole combines with the white light. The slightest ascendancy of the presence of the expansive character induces increased influx, accumulation resulting from this (more especially in inferiorly fused glass); possibly this coloured play may resemble that seen on the surface of mother-of-pearl.

The coloured play on the surface of the mother-of-pearl is produced by the presence of furrows, caused by a regular face of the layers. A furrow offers three active interferences to light—from beneath, from above, and laterally; these stimulate the transition of light. We have already endeavoured to explain the reason of reflection in catoptric substances. The primary force of light is affected as such, manifested in action and reaction. Rays are deflected in parallel planes from the plain surface of a mirror, in oblique or in straight lines, according to the angle the plane of glass presents. The eye, however, does not perceive any change caused by the deflection; for light travels invariably in straight lines, and is affected only in its more primary elements by the angle of incidence; to this extent only light enters. But this change is only known to us as a variation of the course of direction of the angle of deflection. The concave mirror reflects the ray in all directions, spreads it; the mirroring is, so to say, an imaging forth from innumerable distinct surfaces, in gradually marked change of position; each ray impinges on each of these microscopic mirrors, and this must necessarily result in innumerable focal points being formed, the superior with the inferior, and *vice versa*. A total focal point in each ray deflected from the object, impinges in successive order towards the centrum of the mirror, and, in ratio to the increase of the reflection, approaches nearer and nearer to

the perpendicular. At the same time, the increased distance towards the outer rim, this apparent divergence from the common focus, is remedied. Thus all the rays of the picture, though variously deflected, unite at one focal point, and this point is the central axis, for here all the rays cross one another at one point, at an oblique angle to the plane of the axis, and become reflected at this obliquity, and with a two-fold tendency towards the opposite side; whilst, in the lens, this tendency is only simple, strictly in accordance with the convexity of the lens, and for this reason, the centre of the globe is the focal point.

Rays emanate from every point of a body on all sides—above, below, and laterally; and we see objects at each change of position with altered and different rays.

The atmosphere must be full of imagery, too shadowy to become visible; but once a point of support gained, then the return rays come to us from all sides, and the eye sees a complete image of the object, as is the case in our visual organ, on a surface of paper, in a dark room, into which light penetrates through a small aperture, and the object seen is placed outside, and in front of the dark chamber. The organ of vision is impressed with every direction of the ray of light; and thus the opposite directions—from above, from below, laterally, &c.—complete the image. This crossing of the rays of light appears as a polaric interchange; the degree of opposition remains, but the poles are changed.

Direction is the primary polarisation of forces, and this direction is in parallel planes where a unison occurs, or in opposite planes, and in this case they sustain each other in their negative character. Separation follows immediately upon this combination at a focal point, the propelling force is doubled in intensity, the supplying power has augmented, and then each ray, with reinvigorated polarity,

passes onward; and this in the same degree of opposites, as manifested at the very inception of the evolution of the force: for instance, from the centre by two opposite radii, which two radii form the diameter. The apex of the triangle is only another higher centre (focus), but marked by a more nearly related "*primary striving*," and polaric divergence and combination.

The angle of opposites at which the rays enter the eye determine its visual size. Objects at a greater distance transmit to us the more parallel rays; those that are nearer stand in opposite relationship, and combine the rays that proceed from above and below. Hence objects placed immediately before the eye appear larger than they are, for they transmit rays from their extremest opposite points to the eye. Large and small are only determinable by the opposition of the rays and their relative position—in fact, by the angle of incidence upon the focal point. We know of many objects that they are large, and they appear to us so, though the eye sees them small at the distance that they are seen at. The born blind, and those who have recovered sight, confirm this fact.

The convex lens equally confirms this law—that the central perpendicular ray passes uninterruptedly through the glass, whilst the oblique rays only bend towards the focus, which focal point forms itself at a distance equal to the radius from the lens, the segment of which is the convex surface of the lens itself. The ray diverges towards the thicker rim of the lens; there the greatest attraction, and the opposition light needs in its plastic tendency, impels this, requires it, in its process of formation: hence the central rays are not bent nor altered, and in all concave lenses the rays diverge to the outer thicker rim of the lens, and hence disperse. In the focal point, the production of light and heat is increased, greater influx in a

prescribed space; therefore the transition to an intenser light (white light), and accelerated transition to heat. Repletion occurs here at the central point—that is, increased influx of wave points in one moment of time, in quicker succession. The dispersion of light from that point affects the eye more intensely; here, too, repletion—too accelerated a wave influx. The eye becomes dazzled, and at the same time more concentrated intenser efflux, augmented action of increased wave points. The besieging influx is so great that the eye cannot see the colours in their transition to heat. Of this characteristic each flame furnishes proof.

The formation of colour is in nowise only a sensation of our organ of vision. Colour is an actual objective phenomena. Indeed, that which acts, impressed with a change in its nature upon us, must bear within itself a change. The organic power effects only a part of this alteration, the other part is conditioned from without, and from the outward altered state of things. Colours form at the edge of the lens, for they cannot reach the centre. Excessive wave influx of light at the focal point produces white light.

The coloured image formed by the prism can only be understood if we remain faithful to the truth, that light, like everything phenomenal, is but the exponent of endless mutation, sustained by never-ceasing supplying influx. The central ray, the least refracted, is yellow, and conditions the red and blue of the opposite poles. Diminished check, caused by the direction given by the body of the glass of the prism, causes cumulation, repletion, and this induces increased change, where the resistance is sufficiently strong. A dark surface, a dark chamber especially, produces this opposition; so also every shade which indicates greater telluric than solaric power, or a change, transition, to some farther elementary state, not being light.

The central ray is essentially positive in its character, and the rays that follow, experience, in the yellow ray, a change of direction, and the second wave influx separates into a distinctive form and appearance; so also the third, fourth, and other successive influxes, each in its turn changed in its direction by the *antecedent one.* The inherent polaric nature of light makes good its existence by an increased negative polarity, and that towards the thicker rim of the prism, towards shade, whilst it tends to light on the side of the positive pole. The positive pole is represented by yellow, orange, and red, more akin to light, imbued with a stronger characteristic of light. In green, violet, and blue, the negative pole is manifested, with augmented transmutative power. All colours pass from their new state of transition, from light to that of heat. Red is the most dazzling of all colours; for here the positive polaric phase is dominant, at the same time light and shade are here operative in intensest oscillation, but with an ascendancy of the production of light; hence the active vibratory effect upon the eye. Heat is greatest in the red ray; for here the transmutation of light is increased, whilst in the blue colour the supply is lessened. But where the supply is ample, there the darker surfaces produce more heat than the light ones, because they induce greater negative transformation.

The absorption of light, the extinguishment of light, even in transparent bodies, is only a change, a transition into some other form of force, conditioned by even the weakest polaric opposition. To treat white light as a compound of other rays, no reflecting physicist of the present day can admit. These theories belong to a dead, obsolete, empirical school—a school which would even again regulate light by the turn of a screw, and split up light itself with the edge of a knife. *Colour is the index of the*

transition of light, placed between the negative and positive; and where all the colours recombine by the aid of a convex lens, such cumulation, repletion, a grouping of many into one, conditions combined action at one point, the transition into colour is not arrested, but it diminishes; like the formation of primary light itself, it becomes overtoned. Even red or blue rays, combined in a focal point, show more brilliancy and less colour. Darker colours, however, cannot, do not, produce so much concentration of the primary light and its influx, as the lighter colours, such as yellow and others; the latter being those instances where the combination of the most manifold polarity is effected.

In the so-called polarisation of light (but which does not refer to light and shade), it is necessary to bear in mind that each ray is composed of a bundle of an infinite number of rays, and that each ray is again a continuously renewed appearance. In the moments which indicate every striving as an interruption, as a wave point, primary polarity prevails. Ultimately, each wave bears the character of stagnation, or the character of transition (like the diatonic scale).

The division of the ray in the Iceland spar proves that a portion of it has taken another direction—that is, the second inflowing ray is altered. The supply is altered, changed, split into two directions. But this severance enfeebles the supply, lessens the intensity of the action of light. The ray which impinges on a reflecting surface at an angle of 35° to 25°, is split up into a reflected ray, and a ray which penetrates and proceeds onward into space. The reflected ray, resulting from the first contact on the surface, is more positive, possessed of greater opposition in direction; the second, on the contrary, is more inclined to become transformed. This latter combines with the

darkening tendency of the inner part of the glass; but where the ray is again reflected at the same angle of incidence, the reflection becomes invisible—there is too little an opposition to resist the effect produced by the body of the glass, the plastic contractive action of the glass conditions its efflux. Undoubtedly, two different characteristics coexist in the Iceland spar—these are their relative lamellar position, and the planes of which cross each other. The mineral principle in the double spar is not combined into perfect unison: two centres are present, and operate in contrariety to one another. The ray is refracted differently by each position of the crystal, and these changes are continued through a farther and second crystal placed in front of the first; but if the latter be placed at a right angle, they change position, though here, too, only two rays are refracted.

Each change of position of the crystal that is held in front, conditions renewed bifurcation of the first two separated rays; thus, four rays become visible, and this because other and deeper-seated layers in the crystal change the direction of the ray. Thus, for instance, crystals illumined by reflected light appear coloured, if viewed through tourmalin, and the rotation of the tourmalin changes at each turn the colours lighter and darker in the crystals. The darkening medium induces a coloured transmutation of light—darker as the inner layers cover the same, lighter where the position becomes altered.

Quadrangular crystals, when seen through the tourmalin, exhibit a black cross with coloured edges; and round crystals, a dark cross enveloped in a coloured ring. A faint image of the cross is even visible to the naked eye, by the aid of reflected light, the tourmalin producing a deeper shade with a coloured rim. Reflected light exists everywhere, dispersing itself from the surfaces of

the objects in the room, and does not enter directly; for instance, the light spread from the surface of the ceiling when illumined. Reflected light is sustained by a feebler supply, possessing a greater tendency to a transition state; passes, therefore, more rapidly into a state of change; nevertheless, light is always more readily transformed at the centre of the glass of the crystal, for here the greatest energy of the glass or crystal prevails. A white or coloured appearance cannot be produced here. The glass power acts polarically from the centre, and shows in the dark cross the influence spreading towards the edges. Here at the edges and at the angle a greater degree of light may be produced, coupled with a lesser shading of glass power. The coloured glass betrays the transition process from the centre to the edges, or in a circle in the round crystal. Inward narrowing (according to Goëthe), however ingenious, does not explain the entoptric appearance. Colour is produced only by those rays that are neither too replete nor too feeble in the action of influx, and permit the inward polaric play within and below. The too active ray possesses too markedly the primary white light; the too feeble passes too rapidly into another state, and cannot be seen—passes away too rapidly, but throughout, lighter colours indicate a lesser degree of transition. As in chemical compositions, the formation of colours is always accompanied by a fixed ratio of light power, and the contra-action of the material acted upon, which creates the polaric contra-action. Too great a change of place disturbs the purer formation of colour.

The phenomenon of the coloured arch on the dark ground of a cloudy sky is but the transition of the rays of light into colour, generated in the rain drops. The centre of the globular drop offers more resistance, induces greater transition to shade; the rays from the upper and lower

layer of the drop, are reflected, and return uncoloured; hence, we see the coloured arch in the centre of which and above the dark grey tone, as the dominant shade of the groundwork of the rainbow. Each drop radiates all the white and coloured rays, but earthward come only the coloured rays, formed up to a certain angle of elevation from the drops above; as also from the drops below we receive the laterally reflected whiter light, which appears to us transparent, grey, and forms the background of clouds. Rays that enter the centre of the drop are refracted before they are reflected, whilst the lateral rays are only reflected.

The lighter colours are produced outwardly, and that through the thinner section of the laterally illumined drop in contact, and finally the latter are reflected as white rays from this upper surface of the drop. The second rainbow is only a re-imaging of the first. The rainbow also manifests the polarity of light, transition to earth power; hence the violet, blue, green, as representatives of the negative principle; the lighter colours, orange, red, outwards, in which the striving tendency is undeniably dominant; whilst in the darker colours transition is the prevalent characteristic, but even in the lighter colours shade off into brown, showing a transition of light in even the lightest colours, but accompanied by a simultaneous predominance of light.

The achromatic telescope (flint and crown glass, combined too with muriate of antimony) converts the colours by repeated concentration into white rays. The focus collects up the rays, and produces white light, because it induces an increase of supply of light, and that at a smaller point of opposition. In the convex lens lateral rays always remain, which cannot be thoroughly concentrated, and hence appear coloured, severed, distinct. The

convex lens conducts these rays (but possessing a different refrangibility) to the focal point, producing white light, because the opposition at the focal point is less, and the result is excessive supply; hence checked transition to light, or rather transition to colour, overtoned by white light.

The eye receives light not merely as an optical apparatus, but with an inward and proper organic activity, by the aid of which it assimilates light. Hence, colour is at times differently produced in the eye itself. Light is refracted, moderated, by the organic crystal apparatus of the eye, and reconcentrated, resolving all darkening colorisation by this act of reconcentration. But the organic action expands and contracts the whole eyeball at will, and thus regulates the optical act. The image of the object appears inverted on the retina, in a state of opposition, which the organic nature of things invariably requires in the act of assimilation and combination. Thus also the fœtus is placed with its head downward in the uterus; and stomach and jejunum have an upward peristaltic action (during fasting), whilst the food passes downward. In the light to the eye there is an assimilation of the inflowing force, which immediately manifests itself polarically, and, by the contraction of an opposite pole, induces the supply, which, again, promotes the transition; the positive pole cumulates, and, finally, parallel onward flow of both opposites take place (the outward and inward, inorganic and organic), until further on transition calls for renewed opposition. The consciousness of the presence of light awakens in the deeper assimilative organs of the brain as a consciousness of sight, and out of these again the profounder thoughts of inner consciousness; for each attained union conveys to the inward temple of the mind the ennobled influx, for the purpose of facilitating a higher

consciousness. Hence, we become cognisant of light in seeing it, we become conscious of its direction, and its inherent power, and of the effect the object has had from which it proceeds. The existence of light, of distance, and the objects touched upon by light, all awaken in us, as self-consciousness, the knowledge of the creative power of the Infinite mirrored in the finite soul.

TREATISE

ON

LIGHT AND COLOUR.

IN MS. 1852 AND 1853.*

ACCORDING to the undulatory theory, light passes, with its molecules, through the ever-existing, undulating, ether element, and the undulation of the ether and the molecules

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* It is necessary to alter some part of this treatise—namely, that which refers to the reflection in mirrors: the change of position being determined by the reflection, the inverted position of the object seen, whilst the position of both sides is determined by the object itself; hence the sides of the object retain their form and relative position as opposed to the object, whilst the whole object retains its opposite position to the object. From each point of the object rays disperse on all sides; hence the rays impinge upon the mirror—it matters not from whence they come, or at what angle the angle of reflection sends the rays to the eye. Upon the retina, however, the reflected ray from the mirror only impinges, not the rays from the object to the mirror; this latter, nevertheless, continues its activity in the former, hence seen by the retina as a continuation of the reflected ray, and in a double length, and towards the object. This explains the appearance of an object an equal distance behind the surface of the mirror, as it stands placed in front, and each side of the image strictly in front of the image reflected, and, by inversion of the image, left and right changed—the right arm becomes the left. the left the right arm.

are at right angles to each other, and colours depend upon the greater or lesser intensity and celerity of this vibration. Light is compared to sound, and is said to be only a product of vibration, but every elementary power is in a state of aptitude for transition to the next state; and all inflow and streaming carries within it the original polarity, which is manifested as alternate arrest and onward flow, creating vibration, undulation. The cosmic ether, as also light, and all the coarser elements, must be in a state of continuous change, resulting from the influx and efflux of power. Vibration is consequent to us on all but infinitely accelerated exchange; and the ether, like every element, in fact, is the exponent of the process of a force, taking its origin in the primary laws of Being and Becoming to Be. And as Being can but exist as also a Becoming to Be, no power can exist without action, and this action is realised as change of power, in endless succession and onward progress, and transmutation from the finest to the coarsest, and from that to individual distinctive formation; hence every power is at the same time an elementary material. Light and ether are finest, most primary transition elements; and even primary motion, conceived as a primary element of motion, must manifest itself simultaneously as a materiality. The possibility of a transition into the material, is essential to the action of force in its transmutation to a reality, and without which the functioning of force is an impossibility; and this possibility is the finest primary form of every power on its becoming a reality. Thus the eye forms from the rays of light an inward light peculiar to itself, by the aid of which it receives and mediates the influx into the ether investure of our spiritual being, and the transition of consciousness into force.

Light indicates only one of the many states of transition

and realisation of force. The primary cosmic ether is the prior state of transition, pregnant with polaric cosmic influences of all the countless cosmic bodies that are suspended in the cosmic space. The solar power has, then, equally to pass through all the elementary states of finer ethers and of different grades, before it becomes light, and with which the sun throws upon the planets of its system, but, nevertheless, accompanied by the finer ether, out of which light has been created, carrying within it the mighty solar action, and mediated by it.

The infinite transitions which the solar and cosmic powers pass through, prior to their becoming light, we designate by a common term, "ether elements"—and are compelled to do this, as we have no means of separating them into distinctive characters. Light is to the senses the first appreciable transition from the unappreciable, in its transformation to the material, and this in a more contracted, less expanded elementary form. These material elements also affect the material sense, where the finest organ of sense is related to light. But light conveys only the impress of the outward form from nearest and most remote regions of the world; for light possesses the quality of swiftest motion, like the finer cosmic element, yet enters the realms of the material, travelling from body to body, combining all that belongs to the phenomenal of form.

Light brings us tidings from every part of earth's nature, and from the cosmic realm, and mediates, especially as reflected light, all material objects, both the nearest and furthermost to our corporeal existence. The eye, with its nervous membrane, the retina, is a highly potensated sense of touch; the coarser sense dwells in our skin, in taste, and smell. Light mediates the finest bodily impression by means of the eye, and awakens the consciousness of

our bodily existence in the material outward world, and weaves the finest connection with it. In light the power resides which becomes transmuted into the forms of light, and reflected light transmits from all objects an augment of each individual impress of power. Thus light, as a creative power, awakens in us the creative act of our own minds, and we are enabled to recognise, from their outward appearance, the inward being, relationship, origin, and evolution of each object, and equally so of its life and essence.

The reflected images from all forms of the material float through space, and pass onward, entering the infinite cosmic realms beyond. All that is visible is but a reflected image of light, changing into shade and colour, conditioned in this act by the outward form. The senses convey to the inner life of our spirit the image of the outward to the inner soul, where all the infinite points of connection between all beings and things pre-exist. This explains the ready recollection upon the smallest external incitement, and will explain the awakening consciousness of the inner being and life of everything created; of all things as arising and progressing and emanating from the omni-existence of God, which compasses all, and our being too, in its eternal all-uniting presence, revealed in the all-manifold connection of its existence.

From the remotest stellar bodies we receive no special form or image, for only a few of the brightest rays reach us, possessing sufficient force to act upon the nervous membrane of the eye. Hence, we only receive a *bundle*, in narrowest condensation, of rays of purest light, but formless; nevertheless, the images from all bodies penetrate into space, carried thither on dimmest rays, travelling forward to distances beyond bounds, but, nevertheless, luminous as starlight, as soon as the eye offers the neces-

sary opposition for concentration and transition from ether to light, a transformation of the far distant solar power from the primary ether into a luminous ray.

The images of our nearest surroundings, in the first instance, encompass us, visible only where the eye, or reflecting surface, offers an opposition. From the visible form to the eye, space must be filled with images in continuous succession, but not luminous, invisible, until the check received produces the luminous transition. The nearer object appears more distinct and larger, the farther off smaller and less distinct; but great and small are only relative conditions, and owe their existence to the organ of vision itself. The eye possesses in light itself a kindred element, its peripheral existence; hence, it attracts light by the aid of its organic central assimilation operating outwardly, operating upon the influx of the all-sided dispersed flow of rays. The optical nerve-power has enclosed its organ of vision in a suitable apparatus for this function; and by the aid of cornea, pupil, and lens, the contraction is effected, until it becomes permanent. The crossing of the images takes place in the *corpus hyaloidea*, translucid body, but with an expansive tendency, which follows the former concentric action in polaric succession. But from hence the act of assimilation continues in the inner sphere of visual force, and this with renewed activity and contraction from the retina, and at the same time with renewed expansion and crossing of the image. Whether, in this second act of assimilation, concentration or expansion, central or peripheral, are dominant, this alone the inner sense of vision can determine, in reference to largeness or smallness of the object seen.

Rays emanating from the more distant objects cannot all reach us: those rays that centralise and combine, and cross one another at focal points closer to the object,

and then disperse. Only the parallel rays travel into space, but even of these but few reach us with sufficient power to excite the action of the retina. Distance in itself diminishes the force of the ray, whilst partly the rays become weakened by refraction, or by the transformation of light into heat, or oxydisation, or into some other form. All the vacant points that are present in the luminous rays, are filled by the assimilative process of the eye itself in its contractive action, which gives to the eye the power of centralising all the moments of light, but resulting in diminution of the object seen, which is seen less clearly; nevertheless, connected in its parts.

The object in closer proximity becomes large, because a larger portion of the rays enter the eye reflected from the surface, the concentric and parallel rays all enter the organ of vision, and even the faintest are observable. The excessive accumulation of rays upon the retina, excites it to receive and assimilate all the impressions, and this must be the case in the whole realm of light, visual power. The moments of light are attracted by the totality of the power of vision, and hence placed in directest opposition and repulsion; an expansive tendency develops itself in the organ of sight, and this again is communicated to the infalling flood of light—thus nearer objects appear more distinct and large. But the same effect is produced on the retina by a small object, which, in immediate proximity, produces similar effects to those caused by a larger object, resulting from the expansive tendency of the eye in its act of assimilation.

The telescope, with its convex lens, effects the same as proximity of an object seen does. We receive the longitudinal rays through the lens refracted; and thus rays of light, otherwise all but imperceptible, become visible, and distant objects appear large to our sense of vision, for con-

centration and expansion are now both intensified in their action; hence we should be able to bring even far distant cosmic bodies nearer to us, had we but the means of constructing an object-glass of sufficient size and pureness of material, or could we but build a glass of sufficient concentric power to effect this purpose; for even from the farthermost stars rays enough reach us, but so feebly, that it would require a very powerful centralising agency to combine them into a visible form. The convex lens also aids the eye where the tone is weak, so also the concave glass aids in the decentralisation where morbid contractibility predominates, assists the eye itself in its effort to decentralise.

The sun does not primarily emit light: the mightier efflux from the sun is an ether element which precedes the formation of light. The dark body of the sun is now and then shown to us unveiled through the photosphere, in the so-called spots on the sun, varying constantly in size, and generally situated near the equator. The spots show a shaded light, proving an intermediate state between the dark body and the luminous photosphere of the sun. This photosphere forms around the sun, and gives to the solar body a perpetual light.

Like every power, the solar power has its polaric action, expressed as contraction and expansion. The contractive action manifests itself at the very first outstreaming, inducing an arrest, and, from this, again a transition from the ether element of the sun to the form of light; for, in the contractive tendency, the formative character prevails, and that by the very accumulation of the wave points, because every force bears within itself the onward progress of farther development. At the solar equator, the efflux of power would be the greatest; and hence, just in this region, the self-formed luminous atmosphere is again and

again penetrated, broken asunder, probably causing the spots on the sun.

Where the check has occurred, the solar force passes from this state to that of expansion, and that in the primary ether form of its primary action. In cosmic space, the solar rays expand with less contractive action, experiencing less opposition from the finer ether element which pervades this realm. The ray of force, therefore, is only sparingly transformed into light; still it carries to the planetary constructive tendency, the expansive character attained at the first moment of its emission from the sun, the solar character of the influx. In the planetary body itself, however, the greatest check is received by the solar efflux, and at this point the greatest amount of light is formed. The ether rays emanating from the sun, and but sparingly luminous, become highly luminous, are refracted in the atmosphere, illumining this at all points, until, in fullest reflection and play of colour from all objects, the fullest, brightest day is born. The very arrest of the solar influx produces a change, but this attains to its completest manifestation in the combination of the polarically-placed solar and planetary powers.

The new-born light possesses indeed a solar, planetary character, and combines now the more readily with the planetary forms of the vegetable and animal kingdoms, with mineral, and all the products of this earth, combining with the planetary light and heat, with its gases and vapours, as products of the onward creation of telluric transformation of power.

The play of colours, however, manifest themselves as the primary transition of solar power in the finest elementary state, through the most transparent medium, and more materially interwoven in all the infinite colours of visible formation. In this manifold formation of colour, the

polaric development of the primary elements manifests itself, betraying even at this early metamorphosis the combining presence of oxygen.

Warmth, nevertheless, is the mightiest progression of light, endowed with the fullest telluric character, resulting from the closest union of the two. Telluric and solar heat are essentially expansive, but more limited in their elementary action, destined for the development of the planet; and though endowed with the expansive tendency, nevertheless plastic in their nature, and adapted to the formation of the earth's products.* Warm rays are found in the spectrum, combined with those of light, marking their metamorphosis, and the dark intermediate fields (bars), which divide the colour, show a chemical transition to oxygen. Where light prevails in excess, as is the case on mountain tops, in higher atmospheric levels, we cannot detect the formation of heat. Heat is formed at a later period, as the joint product of solar and telluric combination, a transition to the formation of air, resulting from the continuous metamorphosis of light. Heat, like light, has its inherent polaric states, manifested as heat and cold, of which light and shade are the parallels. Only where light comes into contact with a wider surface on the earth itself, the metamorphosis to warmth takes place, expressive of the resolution of the former previous contraction in the earth elements, and formative transformation from this. On the plateaux of the Altay, of the mountains of Thibet and of Mexico, we find the vegetation of the temperate, and even more southern zones, favoured in its growth by the warmth of the rays of light. Upon the St. Bernard and Etna, on the contrary, vegetation ceases even at a

* This has been attempted to be explained by a triple character of the ray—luminosity, colour, and actinine.

less elevation, because the mountain tops do not present sufficient surface for contact; hence only the first contractive state is evoked, in a feebler contact of solar and telluric powers, not the onward resolution and reformation from this.

If even a small amount of contact with an opposing element induces a lesser transformation from cosmic elements into light, how greatly must the transition from light to heat be hindered, where the opposing elements are not sufficiently present. The deep blue sky of the vapourless tropical atmosphere proves this, and a feeble starlight even at mid-day may be observed on Mont Blanc. This shows that the development of light is retarded in the ether rays of the solar power, which penetrate the cosmic space, producing this phenomenon. We recognise in the deep blue the first dawn of colour in the shade, the first transition of the primary light from the primitive ether. Even from these most primary innermost rays we receive the direct effect, where they strike our organ of sight; the others pass by in various directions, and transmit only their lateral light, which the retina cannot perceive as light.

The oxydising property of light is everywhere exhibited —in the colouring matter of plants; in the colour of the blood; nay, even in the bleaching of substances formed of vegetable fibres, and which, when separated from their organic life, return to their primitive mineral state. The sunbeams saturate these with oxydisation, so that henceforth they only feebly transform the ray of light, returning it as white light. In the photographic application of substances, on the contrary, the oxydisation is most active, and more especially in the nitrates of silver and the iodide bromic preparations which belong to this class. But in this instance the oxydisation by the action of the acid has

only loosened the metallic cohesive force, allowing of a quicker combination with the oxydising rays, and formation of colour is from their contact, which action is manifested in all the oxydising transition tendency of light. Photographic action takes place even in a vacuum within the glass vessel, where the atmospheric air cannot furnish the oxygen, but where traces of oxygen gas are, nevertheless, observable after the photographic process has been completed. Similarly, we discover oxygen in plants which have been exposed to the action of light during the day, and exhaled as carbonic acid gas during the night.

Solar power, from its all-controlling, central position, determines the formation of nearest and farthest planets; and this formative process is effected, from its primary inception, by concentration of the planetary expansive forces. These forces manifest themselves as electricity, light, heat, gases, and vapours, irresistibly distributed through space, such as we witness in the expansive bodies of comets. But even here the sun-power present is a limitation, gives boundary line and form to the expansive elements, as the primitive germ of a future cosmic body. But in the farther advanced planetary bodies the consolidated crust appears as the strongest limitation of the inward expansive action of elements; these, in moderated dispersion, penetrate the consolidated crust, and form the atmosphere, the materials of life for organic nature; whilst the crust of the planet continues, from its own proper action, its continuous growth, transforming itself into an ennobled soil for higher forms of creation.

The atmosphere is replete with infinite capabilities of development; this we have already alluded to in former treatises. The solar power incessantly and progressively transforms itself into the telluric elements, entering into the innermost of the earth's laboratory; and the planetary

forces in the atmosphere bear inherently the striving towards incessant transition, preparatory to the individual forms of life of the grand nature around us. The telluric electricity of the atmosphere is, indeed, the most general element of the earth's power, in its transition from fugitive light to a more material elementary condition. Experiments often confirm these transition states. Ozone, of but recent discovery, is a transition element from the atmospheric electricity to the finest gaseous form, possibly combined with oxygen, or related to the nitrous, sulphurous acid; hence, when in excess, so injurious to the organs of respiration, producing catarrh, epidemics, pneumonia.

The solar power transforms the earth-powers and elements into a higher, nobler state of plasticity; even solar light and its warmth must combine more intimately with the crust of the earth, and more especially with the earth proper, and light, and heat. The oxygen of the atmosphere, the most potent of the solar gas transformations, permeates the earth's crust everywhere, combining with the vapour and gases of its inner cavities. This is proved by the transformation of carbon to carbonic acid gas, the metamorphosis of hydrogen into water, sulphurous vapours into sulphurous acid, as also metamorphosis of many telluric bases into acids—all related to one another by their fluidity.

The alkalies and earths appear acidulated; and we find metals, in the form of oxides and salts, ejected from the inner bowels of the earth by volcanic action. The all-encompassing, all-penetrative plastic tendency of the solar power is manifested in acids, in oxygen, as the contractive principle; but this contractive tendency already manifests itself in light, in the formation of a ray of light, which is essentially contractive. Each ray of light, as it presents

itself to us, is but a bundle of concentrated rays, divisible by dispersion and reflection, accompanied by the transition into colours.

PART II.

EACH ray of light is always an infinitely swift repetition of the influx of light. Where there is greater resistance, the influx becomes augmented, by the increased celerity of its ingress, to intensest action; also the centralisation of separate rays must produce this potensation, which we recognise as white light, even in the reunion of polarically separated coloured rays.

Shade is inherent in light itself, as its inward polaric opposition, manifesting itself, as tendency towards formative process and metamorphosis, into nearest subsequent elementary forms. But the finer elements which precede the formation of light, are by no means recognisable by the organ of light, by the eye, and are only, and this exceptionally, perceptible to the finest sensitive feeling in a state related to the magnetic condition, but recognised more decidedly by contemplative thought, and the search of the inward light.

The transition to the first coloured hues of the primitive ether in their early dawn, we have already pointed out in the dark blue of our firmament. The second and deeper shade is manifested in all the transitions into other elements, such as heat, gases, vapour, in every fluid formation and solid substance. When light impinges upon these non-luminous elements or substances, it is stimulated by the very arrest to an opposite polaric condition, presented as such in darkening substances. Goëthe has recognised this undeniable truth, with the genial intuition of the

poet and philosopher, and matured this idea into a leading principle. Colour is the transition of light, and induced by shade; and the solar spectrum is the solar development of light. But shade is not an element apart from light, but, on the contrary, it is its polaric inward action in alternating change of appearance; and the shade elements are the forms of light in its transformation to colour and formative action.

Every arrest sustained by light is recognisable by refraction and reflection, and at same time by the accompanying play of colours, such as each visible object radiates in manifold nuances of shade and colour, such as the prism unfolds in the most perfect polaric form; for we cannot accept the ray of light reflected at an angle of 57° as polarised, but only as a diminution of its onward striving action, and which, on renewed refraction, becomes incapable of farther progress, and disperses into many rays. It is only the ray that impinges directly upon a surface which penetrates the medium unhindered. All lateral rays are checked and divided in their action; for the very reflection takes away a part of its effect, and the point of contact only receives part of the ray. The angles of incidence and reflection are, in the act of reflection, the same, measured by a perpendicular to the reflecting plane; for the angle of incidence determines the degree of resistance to be offered by the reflecting mirror, and this opposition again determines the reflection and the direction given by it. The more oblique the incidence, the more the onward tendency of the ray is in the ascendant, because it only touches the surface tangentically. The perpendicularly impinging ray causes a stronger rebound; only, the central direction checks the ray mostly in its course, because it possesses the least amount of onward and retro-action, and, hence, is feeble in its operation.

In refraction the denser medium produces the greatest degree of arrest, and greater attractive diversion, than in a less dense medium; hence, the plane of refraction inclines more or less towards the central plane, and in less dense mediums the stream outwardly is promoted. Tourmalin consists of laminæ, which, by the rapidly repeated check, give to the ray a double angle of direction, accompanied by a simultaneous enfeeblement of power of the second half of the polarised ray. It is necessary to bear in mind that the supplying influx enters with immeasurable celerity; hence, a second ray is readily formed out of this influx. In the solar spectrum this infinitely rapid influx appears as a polaric expansion, sustained by the many-sided direction, and checked in its course by the prism. In the dense medium the check occurs inwardly.

The prism stimulates the polaric development, not only by the arrest of the transparent medium, but because of its very form. The oblique plane causes, first, refraction of the impinging ray, whilst the base and angle point of the prism present a greater and lesser action of contraction and expansion. It is true, this difference of attraction does not produce division of the ray of light in the interior of the prism itself, because the mass of the base prevails and acts too determinatively; but after the stream has passed through the prism, the increased polaric action manifests itself in stronger polaric expansion. The very check promotes the contractility of the ray of light, which from henceforth, with its striving tendency, is coerced into a stronger antagonism. This opposition, however, makes itself valid as a contra-action in the onward striving, whilst the expansive tendency tends to contraction, evincing an opposite direction.

Infinitely rapid streaming follows in the ray itself, and this again experiences in the prism itself a second check

in the advance stream, which has already touched the opposite wall. Thus the influx is momentarily impeded by the stream that has preceded it, made to deflect, and simultaneously the polaric severance, replete as this is with the transmutation into colour, resulting from the all-pervasive check sustained.

The yellow ray possesses the primary, most intense, influent power, with least polaric transmutation; and the rays that succeed yellow, appear polarically divided from one side to the other—orange, green, red, and blue, with their different shades and most extended contra-formation. The expansive power of colours tends to the red colour, whilst blue represents the contractive phase; hence blue is formed at the basis of the prism, whilst red is formed at the apex.

According to Frauenhofer, the fields of colour are severed by dark bars or planes, and point to the incessant contractive tendency of light in every streaming, and mostly in the act of transmutation. The undulation of the stream of light arises from the alternate action of check and onward current. The twinkling of stars betrays this duplex action; equally so the momentary interruption of the stream of light emitted from a lighthouse.

The colours of the spectrum, and colours generally, possess in their divergent character no positive permanency. Each colour contains within itself the moments of transition into all the other colours, and equally so of the total polaric expansion, though accompanied by the presence of one dominant transmutative tendency. Every surface of a body changes light by the action of the telluric elements prevalent on this surface, and, therefore, polarises light to this or that polar tendency, according to the nature of the body acted upon. Thus the various colours of an object appear to us as an expanded coloured spectrum, though

not in the same order as produced by the prism. White light is emitted, as representing the strongest concentrative action, the least polarisation. We cannot, however, conceive even white light as an absolute primary manifestation, for it must contain, even in its purest state, all the transmutative tendencies of colour, and more especially towards yellow, as bordering on white light. The finest ether element has equally a tendency to form into light, but so fine that it is not recognisable by our eye. The first dawn and form of light is in the dark blue sky of the heavens; here the negative element is still dominant—a lesser degree of concentration, a greater polaric action towards the pristine influx—and which we designate as a negative pole, as shade, inherent in the original polarity of light.

Whatever impedes, arrests light, produces shade, and its transformation into colour. Thus all rough surfaces, which in their indentations and grooves offer the conditions of increased opposition and the resulting change, produce shade and colour: for there are here more numerous points of attraction of light. A polished or smooth surface, on the contrary, diminishes this attraction by lessening the porosity, and the ray is repelled unaltered; and the force of light continues unchanged in its condition, making itself valid by reciprocal repulsion and consequent concentration. A plate of glass resting upon a rough but thick surface of amalgam, gives the purest, amplest means of reflecting light, and accompanied by the best degree of change, because the plate of glass deprives the rough but whitish surface of amalgam of its porosity and the resulting operation.

A surface finely grooved, or wavy-formed, also produces a coloured play, such as we witness in thin layers of glass, of mica plates, in the mother-of-pearl: the undulated wavy

surface, semi or quite translucent, acts prismatically, whilst the grooves produce, by their very indentation, a change, a metamorphosis of light. The coloured rings produced by the contact of two lenses, result from the uneven surface produced by the pressure. Here, too, in the grooves, the action of light is impeded, checked, and combined with a prismatic refraction, an effect produced by the rings which expand circumferentially, eccentrically, from the central point of contact.

All colours vary even where the eye cannot detect a difference. No colour remains the same: the colour of each ray, of every flower, or of any given substance, of the blue of the sky above, of the many shades of the forest, of the roseate of dawn upon the horizon, constantly change. No colour is fixed, and no dye is permanent as a colour —they all alter, change. Endless change and variety exists in colours, present in all nature, supplied by the influx of the all-manifold power and principle of creation. No colour possesses an absolute character: its hue is not constant. White light bears within it the yellow hue, and yellow shows a weak orange and red as constant concomitants; thus also blue and yellow appear in the green light, violet in blue, and red in violet. Thus infinite transmutative action manifests itself in the formation of colour, infinite manifoldness in all; and we may as well speak of billions and billions of colours, as of seven, or five, or three of the, to us, most known and recognised colours.

Colours are indebted for the greater part of their distinctive character to the self-active function of our organ of vision, which transforms the influx according to its individual character. We might, adopting this view, ascribe to each colour a psychological character, more especially as we have proof how variously the human eye sees colours. With some the most opposite colours are

mistaken, even blue and red; for here the organ of sight itself converts the negative pole into a positive, and *vice versa*, according to the dominant character in the retina itself. Complemental colours, such as green and red, which succeed each other, where this or that acts strongly upon the retina; these self-formed colours of our organ of sight are perhaps the most convincing proof against the theory of primary colours forming pure light by their combination. Pressure on the eyeball produces colours, which pass through all the hues of the rainbow; the eye possesses its *proper organic light* in the nerve electricity of this highly sensitive organ; this nerve electricity permeates the coarser envelope of the optical apparatus, which owes its form to this inner ether element. The inner light of the eye is the organic element with which the outer light combines, and by means of this the assimilation is mediated to the mental life of our very spirit itself. But this transition into light does not pertain exclusively to the eye, it is present in every electric nerve ether of organic beings, manifested as a metamorphosis into light from the prior state; and the innermost finest elements of our inner soul evince their action in expansion and contraction in this ether element, and produce light, though of the purest, finest character, as the transition from one state to another. The born-blind, also the somnambulist, distinguish colour by the touch of the finger points; possibly not as colour such as the eye sees, but as the *transitive state of light*, without reference to form and condition. But here, too, an organic ether light mediates this, which, in fact, the somnambules see emanating from the finger tips of the magnetiser.

And now, as to the imagery in dreams. Whatever our sensitivity recognises as light, in any region or condition of the phenomenal, in any state of its activity in the

waking or dreaming state, this must possess a reality of the element of light, and this reality exists in the ether organic light of the organ itself. Every impressed condition of the nervous system in dreams is the reaction of the many impressions of the waking state, and external action, as a continuous self-excitement of the nerve power itself. Each condition changes the ether element, varies its action and transmutation, and this in accordance with the law which each respective condition or state requires to form light and shade and colour into imagery, which then becomes organised, recognisable by the nerve power, woven by its proper action. These inward images become comparable to those recognised by the eye itself; for the eye only receives an image formed by reflected light, such as the object seen gives reflected from its own proper form.

White light, as well as colour, is not merely received by the retina, but is re-formed, re-born out of the union with the organic light, and becomes changed according to the state and character of the organ itself. Thus the dazzling light appears to the albino and to the owl as darkness, and darkness as light produced by the organic light, which produces inward light, by the aid of the slightest quantity of outward light. A strong and concentrated stream of light is recognised by the retina as white light, even where this concentration results from the merging of the prismatic colours into one single ray; and where we combine all these colours by a lens, the whole of the polaric stream of light is reconcentrated into a focal point, and the retina transmutes this concentration into a sensation of white light. But this mergence of colours produces always a dim white, never a pure white, and which would not take place if white light were only composed of coloured rays.

Still more imperfect is the seeing where the blending of primary colours occurs upon a disc set in motion round an

axis. The rapid succession of impressions leaves the former still operative, whilst the recent one takes its place; hence, all the polaric colours concentrate into one current, and these experience an equally concentrated action in the nerve itself. Many optical phenomena are based upon his blending of impressions: thus also the objects on the rotatory disc; also the light stripe observable on the rapid passing of an object; the aberration of starlight, the apparent accumulation of stars towards the east, is produced by the rapid rotation of the earth—the impression of stars that have past the field of view becomes added to that of those already seen.

White light is never absolutely white, and can only be considered as a very light yellow; and yellow contains, as does every colour, the whole expanse of polaric development of the colour spectrum, and exists, no doubt, as a primitive germination. This possibility of development has induced the error of giving to the coloured rays the primary character of pristine light, and led to the theory of white light being but a combination of colours, and has farther given rise to the theory of the absorbing and emission of coloured rays by the coloured property of certain substances.

Prismatic colours are produced by the check which light sustains in the crystal itself, though this inward retardation is supported by the presence of the prism. The inward contraction of light is its primary plastic tendency, and manifests itself in the transition to colour. The feebler the formation of light—such as exists in the cosmic space, where the solar rays of the sun-power traverse space in their primary transition form and tendency—the greater this inward retention in the flow of light itself. The dark blue of the skies confirms this effect of the arrest as the first dawn of colour on the dark ether ground. The

colours of bodies are distinguished from those of the prism, which are as the product of the metamorphosis of light itself, as arising from its union with the telluric powers, and which, again, exist on the surface of the bodies themselves. The degree of transition produces each individual colour, which, again, makes itself known to us as transformed light, reflected from the bodies themselves. Each colour contains all the hues of the other colours in it, and this because it possesses the transition possibility towards every polaric expansion; and hence each colour really contains within itself the whole of the solar spectrum (colour spectrum), though only in its faintest state; and, therefore, each colour—blue, yellow, red—when concentrated to the focal point by a convex lens, shows a lighter hue, approximative to white light.

All colours, prismatic as well as those reflected from bodies, are, as we have already recognised, in a constant state of change, altering momentarily by the influx of light, which are at times scarcely distinguishable. Colours are constantly renewed, re-formed, with the speed of thought, and are, therefore, permeated with the primary light and its ether element. Wherever there is a concentration of coloured rays, there the influx of the primary light and ether element establishes itself, and creates a lighter and purer light from this, which permeates the coloured transformation. The more developed spectrum indicates greater influx of the supplying stream; and, when concentrated, produces a brighter, purer light than that formed by the isolated colour—white light being regenerated, though less intense in action, in consequence of the metamorphosis to colour that preceded it.

The Rainbow is a prismatic phenomenon of colour; each drop radiates all the colours of the polarically developed

spectrum. The more powerful the action of the sun, unobstructed by the presence of a denser atmosphere, the greater the drop formation, accompanied by the amplest fall of rain, the more clearly the colours develop, even to the more delicate hues. Each drop refracts the ray it receives in itself, and then reflects it with fullest power, supported in the act of reflection by the dark background of the cloud.

The full image of the sun floats upon the rain mirror, and fills the surface of the raindrop with a ring-form radiation, of which we see the half, formed out of the arch of prismatic raindrops, and each drop, like the bow itself, sends forth all the colours in most expansive dispersion. Our eye receives only one developed ray, the others passing either too high or too low. At the base and innermost portion the darker hues are always blue and violet; for the falling raindrop, as it descends, is drawn out into an oblong shape, larger at the base, smaller above, and the thicker part acts similarly as the base in the prism, aids the negative pole as shade; the smaller part, like the apex in the prism, supports the positive pole, representative of the energetic striving of coloured light.

If we could invert the spherical layers of drops, which transmit to us the blue colour, the same layer of drops would transmit green colour, and the blue would disappear altogether; and, continuing the depression, yellow, orange, and red would successively strike the eye. But this downward movement exists in all the layers of the rainbow cloud; and thus from the lower drops we receive the blue colour; from the higher, green and red. No doubt the eye must pass up and down to grasp the image of the prism, and the eye, in fact, does do this in quickest succession. The prior impression joins the former, completing thus a total image upon the retina. The slightest change in the position of the axis gives a new field of vision; and

in viewing a large objective field, the eye involuntarily scans all the various directions necessary for the visual comprehension of the objects seen; but where one particular object is singled out, here we soon learn that the others withdraw from our visual power. The successive quick scanning of objects, and the uniting of the impressions on the nerve tissue, retina, combine the most multifold into one; and we owe to this act of combination the full glimmering image of the coloured rainbow.

The drop transmits, besides the coloured rays, rays less coloured, which are formed by the lateral feebler refraction, and commingle with the others, and this because the varying radiation cannot sufficiently extend into polaric development. From the series of the drops above and below the arch, we receive only those mixed rays, recognisable as the dark gray of the background of clouds, from which the glimmering coloured arch arises, and possibly stimulated under intenser light of the sun, in its electric tension. But even the lateral rays become more refracted in the larger formed drops emanating again from these, marked with augmented polaric unfoldment, as a prismatic image, and a second rainbow is thus formed. In tropical countries others are frequently seen beyond these, as repetitive annular images of the sun.

The rainbow is seen in every change of position of the spectator: on approaching, the colours appear higher; on distancing, lower; for the gigantic image of the sun is magically mirrored forth upon the dark field of the cloud. An electrical tension of the atmosphere often gives to the colours a deeper hue, and the raindrops themselves swell into larger sizes, by the aid of the electric, contractive, formative power in the dark background of the cloud.

A rainbow in the morning forewarns the husbandman of coming rain; the rainbow at sunset prognosticates a fine

day. In the morn, the solar power acts with twofold energy on the elements gathered up during night; for sunlight promotes the formation of gases from the moist telluric elements, and where rain falls in the presence of sunlight, this latter permeates the bank of clouds, increases the vapour formation and the electrical state of the atmosphere. In the evening, on the contrary, the vapours descend as the sun departs, obeying the law of gravitation which now prevails; and where gravitation forms the watery vapour into prismatic drops, the fall of rain that follows may be regarded as a critical descent of moisture, as an exhaustive precipitation of the humidity in the air, repelled and condensed by the gases of the atmosphere, and a bright day then follows as a necessary result.

We have in studying transparent bodies, primarily to consider the elements of air and water. In the ether space, the solar power scarcely forms to light, for here the too fine medium does not offer sufficient resistance to produce light; but in our planetary atmosphere, the telluric opposition exists and transforms, by resistance to the sun power, the primary element into light, completes the union of the solar and telluric forces. And the very exciting of the ray of light itself, coupled with the expansive nature of the air element, determines the free transmission of light, which undergoes no alteration but that of moderate refraction, accompanied by a minimum degree of transformation into colour. The billowy, undulatory, elements of the planet are too akin to light, and favour the ray of light, causing a minimum of change; and an electrical atmosphere with a tendency to telluric light, imparts to sunlight the next mediation in its passage through its substance, and mediates equally the next state of elementary gas formation, also that of heat and vapour.

The expansive elementary tendency still exists in water,

though accompanied by a formative, cohesive, contractile act. In water, an electric action continues, arising from the earth, but above all from the bottom of the sea, and from the deepest regions of the earth, combined with these elements, by electrical vapours, the earth gases; as the conductor of electricity, by carbon, sulphuretted hydrogen, and hydrogen. Even the unceasing production of water from the gases must produce an electrical effect, resulting from the very act of evaporation, and the friction of particles in constant motion.

Wherever these expansive elements are predominant in the solid masses themselves, there the transition and mediation of a ray of light becomes possible. Even paper, saturated with oil or water, becomes demi-transparent, and other finer textures equally so. The transit, the passing through of light by the presence of this expansive element, is facilitated, where all the pores become filled with the saturating fluid; and even the more opaque intervening substance of the tissue itself acts by means of attraction, though certainly not by furthering the metamorphosis, and darkening of the penetrating ray of light.

Transparent crystals owe their conductive property of light to a similar union of the expansive elements with the solid substance which envelops them. The crystalline water acts like the conductive exterior element—it has formed the crystal envelope out of itself, and permeates it at every pore. But this expansive fluid element acts mostly dynamically, entering the whole of the crystal, imparting to each consolidated wall of the crystal the approximative relationship of light, causing, by its contractive character, stronger refraction; but at the same time giving to the ray of light the properties of receptivity and refraction, similar to that which the prevalent crystalline humidity possesses.

Certainly the greater refraction of the crystalline contractive mass stimulates more actively the metamorphosis of light into colour, by favouring the inward arrest of the ray; but the obscuration is not carried to the same extent as it is in opaque bodies, where the transition is from light to heat and to oxygenic conditions. Crystalline formation is traceable even to microscopic atomic forms, and thus gives to the whole mass the competent clearness in the conduction and refraction of light.

The crystallisation of ice places most prominently before us the process of crystal formation. Water, representing the expansive element, becomes permeated by the contractive telluric power, and parts with this element in the act of formative expulsion, hence manifested in the jutting crystal points representative of the excessive outstreaming of the expansive force; whilst the contractive action is represented in the hollow interstices. Ice is formed out of infinitely small crystals, and each crystal is in itself a frozen atom, with similar form of jutting out points and contractive interstices. The expansive element of water permeates the whole mass with its dynamic influence, and manifests itself as an undisturbed conductor of light. Nor is electrical operation wanting, such as the concentrated action of forces require in moulding during their formative, creative processes. Sparks are often seen on the ice during intense cold, and the friction of two pieces of ice produces electrical warmth. The crystal formation of salts is similar. Created out of a fluid, the contractile force moulds itself into shape by the expulsion of what is foreign.

The simpler the plastic substance is, the nearer it approaches to an elementary primary type, the less its effect upon the metamorphosis of light, and the less it produces of shade. To these elements belong the alkaline substances, acids and their combinations in the neutral

salts; carbon also belongs to this group, and this we see in the diamond; and even may add some of the earths, such as chalk, silica, and alumina, which may be classified into one group with these. But where the substance is of a more compound, or more advanced in its development, as in metals and their combinations, or in organic tissues, the metamorphosis of light is greatly stimulated, light becomes obscured, changes into colour, and into the transitions of the next elementary forms, of heat, of oxygen.

The saline crystals are constantly produced out of the crystalline fluids. The mixing of the crystalline waters and the earthy substances, produces a turbidity, darkening, and decreases the conduction of light. The electric influx exercises, on the contrary, a strong influence on the crystal formation, even altering its shape. Light itself accelerates the crystal formation, as it combines with the inward electrical action. Electricity, indeed, plays an important part in the crystalline formative operation of nature, but more especially in all transparent structure. The inner electricity combines with the inflowing light, and gives by these means to the crystalline body a greater conductibility of light. Electricity prevails mostly in the crystal investure, and imbues it with transparency, by means of this electric combination with light.

The eye itself confirms this principle in its marvellous crystalline organic formation, shaped out of lamellous membranes, which assume in the lens, in the *corpus hyaloidea*, a definite crystalline shape; the organ of light is permeated with transparent fluids, the vitreous humours, which impart to the membraneous texture the dynamic elementary force and tendency, inducing conduction of light; and the electrical ether light of the optic nerve increases this lucidity of the membranes, for it created the organ, and is everywhere present, receives, mediates,

and conducts the external, outer light. This electrical sensitivity, which has given to the eye its character, is constantly asserting its presence in the function of sight. The electric piercing glare of carnivorous animals, more especially of the feline race, becomes frequently luminous in the dark; and the piercing, also darting, glare of the human being in rage, in madness, in fever and delirium, even in strong moments of passion, is glistening. The glance of the eye imparts, above all, the organic magnetic power, and somnambules feel the radiation of the magnetising eye, when directed towards them by the impulsive will of the mesmeriser.

All crystalline formations are interwoven with electricity, and manifest the unfoldment of the concentrated inward electric power, by the aid of the divergent crystal points, parallel in its nature to the coloured spectrum of a ray of light, proving the polaric development and transformation of light. Electrical light radiates from the jewel, the diamond. Closely united with the prismatic reflected light, it extracts the magical brilliancy of the jewel without uniting with the former, acting by its electrical nature on our nervous tissues. Each jewel retains thereby its individual character, well understood by ancient observers, and in the Israelitic Urim and Thummim, this principle was worshipped.

Somnambules see the electric light emanating from the crystal points, variously distinguishable, according to the nature of the mineral; and friction increases this streaming forth, which the electrical disc of glass has amply proved. Many crystals, such as quartz, evolve, on being rubbed together, an electrical sulphurous and phosphorous vapour; and in some the solar power increases the electrical activity, rendering them visible in the dark. The electric, condensed, formative force appears to be the vital energy

of the mineral kingdom individualised in all its varied products, and more especially in the crystalline polar development. The condensed action of power of the ether element, in its metamorphosis to light, bursts forth with an explosive force. This condensed action and force we have designated to be electricity, different in character according to the formative powers from which it is evolved. In this character, electricity appears organically potensated already in the vegetable kingdom; and as the highest vitality in the electrical nerve ether of animal sensitivity, progressing onward to the intellectual light of our mental being, to the human mind itself.

In the transparent crystals of our rocks, the expansive and contractive tendency of formative creation, such as we witness in the saline crystals, is similarly represented by an expansive element within that crystal investure—the enclosure itself being a contrative husk, which, again, is determined and shaped and permeated by the expansive inward power, rendering the crystal fit for the conduction of light, such as the expansive element requires. But the crystal of rocks is more closely allied to the telluric contractile formation, and, therefore, shapes the crystal envelope the more firmly into a consolidated covering, and in polaric opposition to its expansive contents. We find, nevertheless, the humidity, the water, though less in quantity, present in nearly all crystals. Many, embedded in mountain layers, have, like these, been deposited from the sea waters, and have been moulded into mineral cohesion, and, by the penetrant planetary power, formed into consolidated masses.

Yet, wherever a compact mass arises, it is always prepared in the finer elements, which consolidate gradually by contraction into the transformation forms of the newly created mass, and invariably require to assume the fluid

form, in the drop formation, before the firmer cohesion can be attained. For this reason, humidity is a necessary accompaniment of crystal formation in rocks. In the flint, horn-stone, the microscope discloses two different fluids, which, by concentric rings, deposit their crystalline envelope, and thus confirm the never-ceasing crystal formative process.

In many crystals no water can be detected; in others 2 or 3 parts in 100. The opal and zoolite contain 10 parts; the staurolite, 15; wavellite, 26 parts to 100. The crystal forms are mostly filled with gases, or atmospheric air. In all these instances the air element represents the polaric expansive tendency of the crystalline formative activity, and determines the crystal envelope in its conductibility of light; similarly the air element possesses this faculty. Electricity, however, supports this light-conducting character; it is the determining power, the inward individual crystal light, and, at the same time, the formative force of the crystal.

The pulverised, broken-up, crystal becomes non-transparent powder, often only a chalk powder. The pulverisation appears to have destroyed the inward character of the crystal; for its being consists in the polaric condition of its expansive element, and the consolidated incrustation enclosed. So soon as this relation is destroyed, the formative power of the crystal loses its purport, and also its electric condensed action; hence, the crystal becomes annihilated as a conductor of light, becomes opaque.

The brittleness of glass and of transparent crystals is owing to the slight cohesion of the microscopic crystals, which constitute its mass. Each minutest crystal is encased within its own walls, and completely consolidated by a rapidly contractile, telluric action; but this very contractive act prevents the reciprocal transmission and media-

tion, such as the atoms of other substances, for instance metals, possess; for here all the atoms were brought forth from their common source of power. The lamellar structure of the crystal points to a distinctive and cleavage formation of the crystal itself, formed out of cuticles. Even the diamond, by a dexterous hand, can be cloven into layers, and the diamond cutter has carefully to consider the cleavage in forming the facet. Hardness and brittleness together give to the disc of glass an easily excited vibration, resulting as a consequence from the feeble cohesion of the parts, and increased by the rapid cooling of the crystalline mass during its manufacture. The vibration of the pane of glass transmits the polaric extension of its inner substance to its surface, as is confirmed by the chladnic, sonorous figures. They present themselves, indeed, as the shadowy images of crystallisation, regularly called forth by each pure, distinctive note, irregularly where two nearly allied notes are struck; for here they interfere with each other. At each crystalline formation the polaric powers develop according to the law of opposition, multifoldly repeated, and during which process the opposite points remain negatively and positively electric.

In the opaque crystal the expansive tendency has united in its elements with the contractive elements, and the mass possesses in all its atoms a two-fold formative direction, represented as neutralised parity, unity, and similarity of the substance. But this blending together signifies a progress in the individual formative striving; hence the penetrant light is at once transformed on the surface of the body by the action of the individual force itself, becomes turbid, and passes on to a next following elementary stage, but more especially to that of oxygen, and the more penetrative and deeper seated individualisation of the

telluric substance in oxydisation itself; and this by the closer union of the solar and telluric principles.

Nevertheless, the electrical, condensed, formative striving operates not less dynamically in the sphere of the darker mass of the crystal, unfettering itself incessantly, according to polaric laws, into polaric unfoldment. All mineral products contain within themselves the crystalline character, and in quartz, marble, and calcareous spar, this characteristic is more especially developed, as also in the wonderfully formed basalt columns, shaped out of plutonic molten masses in a telluric soil, at times thrown upwards, at other times horizontally deposited. The fullest mineralised coal is also crystalline in its form, equally so the remarkable and varied shapes of stalactites. Amongst the metals, the more brittle incline to this state. For instance, steel assumes this character by the quicker cooling which it undergoes during its manufacture. Metals are constantly associated with minerals; so also coloured jewels and precious stones—and this, too, where metals are found in their native state; and often the presence of crystalline formative striving is betrayed in noble and baser metals. Nay, even the granitic masses formed out of crystalline particles show in their gigantic rock character a crystalline formation in the masses themselves.

And from the mineral kingdom the crystal formation carries its distinctive character up to organic creation; betrays itself in the leaves and flowers of plants, in the microscopic shell-covering of the infusoriæ, and the consolidated envelope of the moluscs and crustaceæ, in every skeleton of the animal kingdom, harmoniously ennobled even in man himself. The cilia of the infusoriæ, of the rotatoriæ, are but the forthstreaming of electrical points of movement, and which are transformed into feet in the acari; and the extremities of the vertebrata prove this

electrical, irritable character in their organs of locomotion, polarically unfolded (left and right). Indeed, the organs of the animal and human bodies proclaim the polaric expansion of the formative powers, and in their highest development they still point to their primary germination in the crystal form of the mineral kingdom.

The refraction in the transparent crystal increases in proportion to the conductibility of its primary substance. Thus, in the diamond, where we have the purest carbon in the highest state of mineral contraction, this law prevails. Combustible substances possess the greatest attraction for oxygen, and hence also towards oxydising light. The stronger the telluric contraction, and the greater the combustibility of the light conducting material, the more powerful the refracting power of the crystal will be.

In semi-transparent crystals, the pure crystal formation, with its predominant, operative, expansive, inward substance, acting upon the contractive consolidated envelope, disturbs the conductibility. The pure crystalline formation does not in this instance penetrate to the final atoms, nor does the expansive element sufficiently maintain itself against the consolidating rigidity of the mass of the rock itself. It cannot penetrate to the final atoms that enclose it, and awaken the conductibility of light in the same manner as belongs especially to the freely stirring elements of the cosmic ether, of the atmosphere of the earth, of gases, and of water itself.

TREATISE ON LIGHT.

IN MS. 1862.

REICHENBACH'S *odic* light, arbitrarily designated by him as such, is in fact only the individual power of each formative act in its polaric formative condition and development. Power cannot otherwise manifest itself than in a polaric character, as divergence in opposite directions, and transmutation and creative arrestation in endless modulations. Each individual creative power is marked as a creative self-acting centrality, and this more especially in minerals than in organic forms. The odic power must act magnetically, attractive, on its surroundings, representative of the peripheral, corresponding to the central. In the crystal, expansion and contraction are manifested as the angle and plane of the crystal, repeating themselves in all the forms of animal and vegetable life.

The odic power, however, must, owing to its individual character, be slower in its operation than the electric action, which, marked in its general telluric character, possesses dominantly so the tendency of direction, as more extended transmutation. The odic power is, however, both in organic as well as inorganic formation, manifested in flames and luminous jets at the crystal points, and also at the finger tips of the magnetiser. Equally so, it emanates from plants and other formations, altered in each body it

emanates from, yet sufficiently present to be recognisable to the sensitive and magnetised person.

The odic power and its light, individually manifested in every element and formation, presents itself to us as the never-ceasing supplying influx of the primary elementary power, and the inflow from the primary creative forces of the ever-existing primary ether; for nothing exists as a permanency—all is becoming to be, progression, transmutation: hence the supplying stream must be invariably a transition to the individual form it nourishes; and the many forms of transition exhibit themselves in magnetism, electricity, in light, in the very vibration of the ether element, as it flows back to its source, and yet retaining their individual character, suited to each distinctive formation and organism. Thus light, air, water, crystal formation, the forms of plants and animals, as also the human organism, all betray the presence of the odic light, representative of the creative primary power in its special fulness of transition—vibration indicating the inflow and outflow caused by the supplying element that pours itself into every formation. Equally so, the different colorits of effluent light, as in water, or in the crystal, in plants, in animals, prove this, each though distinctive in its character, as shown by the colour and particular oscillations of each body.

Light emitted from different substances—crystals, plants, the bodies of animals—occasionally appear in the form of sparks, which, in fact, are only small central points exploding: they are moments of form in their state of transmission to another state, disturbed in their process, hence centralising. The primary ether inflow, in the act of being centralised, disperses in distinctive central points, and these explode. To this I attribute the phenomenon of falling stars, which proceed from the electric belts, and in

which a widely dispersed tendency towards a mineral formation is observable. Luminosity is only noticed in the animal kingdom, in the invertebrata; for here the formative act sustains an accelerated change, and a lower point of support for the inflow and outflow of the supplying stream, and this owing to the less perfect organisation of the individual animal formation. The supplying elementary influx predominates over the organic powers of assimilation.

Light is the continued transmutation of the cosmic primary ether, as also of every special operation of power. It is true the eye does not distinguish these special acts, or only very feebly, as witnessed in emission of the odic light. Light diffused throughout the cosmic space is a transition element from the infinite, ever-inflowing, primary ether of the formative creative influx, transformed into the manifold forms of the special, visible, and ponderable—into heat, gases, fluids, up to solid substances; hence the immense cosmic space is pervaded by infinitely manifold streams of light, emanating from all the cosmic bodies, but more especially forms from the solar globe. As we receive and comprehend light in our consciousness, the presence of these bodies becomes known to us; so also the other forms of nature. The first primary ether does not convey the impressions of the manifold special forms of the creation: they are first manifested to us by light, because light is the primary transition form of these elements in their transmutation to shapes of phenomenal world.

With the transformation into light, the possibility of knowledge arises, and the created forms of nature are grasped by our limited capacity for the first time; the perceiving of the endless inflow of the creative power into creation becomes known to us. Light heralds God's creative power in nature, and hence in our mind becomes

the mightiest representative of the Infinite in the realm of the finite, of the all-manifold reality of the created; and the finite again marks the infinite course of never-ending progress, development, of the all-creative presence, power, and might of God.

HISTORICAL AND INTRODUCTORY ESSAY

TO

DR. JENCKEN'S TREATISE ON

ELECTRICITY AND MAGNETISM.

BY

H. D. JENCKEN.

HISTORICAL AND INTRODUCTORY ESSAY.

PART I.—ELECTRICITY.

THE subject now before me is so vast, comprises an area of such extent, that I feel a hesitancy in preluding the translation of Dr. Jencken's treatises; nor should I be able to master my reluctance, but for the necessity there exists to preface his work by some introductory remarks, sufficiently ample to guide the reader to the standpoint he has taken, and to enable a comparison to be made between the theories of the thinkers that have preceded him, and the theories he has adopted or suggested.

The history of electricity is of very recent date; and though we have the accounts of Thales, classifying substances according as they assumed the property of amber, ἤλεκτρον—namely, that of attracting light substances after being rubbed, and which property Theophrast likewise paid attention to—it was not until the seventeenth century that WILLIAM GILBERT first (1600) took up the subject with vigour. To him science is indebted for several important steps in advance. He not only classified a great many substances as electrics and non-electrics, but he pointed to the difference between magnetism and electricity. To the

magnetic properties he ascribed a formal efficiency, a form of primary globules.

About the same time, Otto Guericke, of Magdeburg, studied the properties of electrical bodies, and fixed the law that electrical forces attract and repel one another. From that time until the year 1709, no advance was made —Hawkesbee being the first to break ground; and in his work entitled "Physico Mechanical Experiments," he alludes to the property of electrical forces—namely, of attracting and repelling one another.

The dawn, however, of a brighter day was fast approaching. M. Dufay (1733, 34, and 37) gave his attention to the attraction and repulsion of chemical forces; and his report to the French Academy thoroughly drew the attention of the scientific world to these curious phenomena. To the polaric forces, he gave the names of vitreous and resinous electricity—two kinds of electricity, as he designated them, which chance had led him to discover. Grey (1729) had in the meantime ascertained that certain substances conducted the electrical fluid, whilst others did not; and his elegant experiments by suspending an ivory ball, first by a hemp cord, then by a silken thread, are mentioned by Whewell with evident pleasure, as marking an important step in advance.

The Leyden jar or phial, attributed to Cunæus, of Leyden (1746)—but in the invention and the perfecting of which Muschenbroek and Kleist took an active part—may next be named; for the invention of a receiver of electrical fluids formed quite an epoch in the history of these discoveries. The phial is simply a coated glass vessel, lined with some non-conducting substance, such as sealing wax; and the electrical fluid is thus retained in the vessel, until called into action by an exterior point of contact.

Muschenbroek, in writing to Reaumur, gives an amusing

description of his agony on receiving the first electric shock, and declares that not for the kingdom of France would he take another. This dread of electrical shocks was, however, soon mastered, and Abbé Nollet succeeded in passing a shock through 180 men of the Royal Guards at Paris. The electrical kiss, as the spark was called which is produced from a living organism surcharged with the electrical fluid, became the common and most attractive experiment all over Europe.

In 1747, the celebrated Dr. Franklin first gave his attention to this subject, and he has the merit of pointing out that the inside of the Leyden phial is electrised positively, the outside negatively, and that the shock is caused by the equilibrium between the fluids being re-established the instant the outside and inside are brought into communication by a conducting medium. The terms positive and negative electricity, which he first employed, have been generally adopted by the public, and remain in use to this day. Besides this theory, Franklin proved the identity of lightning and electricity; invented the paratonners; and farther suggested the induction of electrical currents, which Æpinus and Wilke farther developed. Volta subsequently gave his attention to the *condenser*, now so much used in electroscopical inventions.

Scientific inquiry had by this time gained strength. Watson and Canton had fused metals by electricity, and Beccaria had decomposed water. In St. Petersburg, Richman had expiated with his life the risk he exposed himself to whilst examining the effects of lightning upon the metallic rod, which he called the electrical gnomon. Despite this accident, Watson and Harris continued to experimentalise on the induction and conduction of electric fluids from the clouds, and these discoveries were practically employed by the Admiralty—Mr. Snow Harris, afterwards

Sir William Snow Harris, with the sanction of the Government, causing conductors to be fixed to the masts of several vessels of war.

But I must step back a few years, and name what M. Coulomb suggested and invented. To him electrical science is deeply indebted; for he established three great points:—1st, That the attraction and repulsion of electrical fluids or forces are *inversely as the square of their distance*, similar to the laws that regulate the force called gravitation; 2nd, That bodies electrically charged lose their power, partly by the atmosphere holding particles of matter, which acted as conductors, and in part because no insulator could hold absolutely the electric charge for an indefinite period; 3rd, That the surface, not the body, of the vessel contained the electrical fluids—that a thin, hollow sphere would hold precisely the same electric force as a solid globe. The law of the inverse square of distance, Æpinus of St Petersburg had about the same time accepted as proven; and his endeavour to satisfy his mind on the laws of electric forces led him to admit the mutual repulsion and attraction of particles, which he finally adopted as the fundamental principle of his theory. For the theory of the mere abstraction of a fluid had led to this difficulty —namely, the transmission of a fluid involved the action of another force beyond that of the mere abstraction of the negative electrisation; for, as Whewell justly remarks, the alternative presents itself of either allowing the existence of two fluids, distinctive in their character, or that the effect results from the repulsion of bodies themselves. Subsequent experiments have confirmed Æpinus' theory; and Coulomb (1788) and Henry Cavendish (1771) have farther dealt with this question. The crucial test, however, of independent experiment, confirmatory of Æpinus' theory, had to be applied. This Cavendish succeeded in

furnishing, by establishing the fact, that in a given point of the conducting medium, like the point of a radius of an infinitely small sphere, the tendency of the fluid to escape will be enormous. Such, indeed, is the case at the wire end of an electrode; hence the translation of the fluid from one pole to the other.

It is very instructive to follow the inquiry into these great laws, and watch how, step by step, we approach some greater field of view, that opens as we advance. Robinson (1769; Works iv., p. 68) and, subsequently, M. Mayer (Biog. Univ. Coulomb, by Biot) concurred that the electric force was as the inverse square of distance, and the elegant *torsion balance,* invented by M. Coulomb, enabled physicists to verify the extent of electrical force with the greatest precision. It was M. Coulomb who employed the *tangent* plane, which he used to test the force of the surface action of electric fluids. Forty years later, M. Poisson, availing himself of the labours of M. Biot, communicated to the *Bulletin des Sciences* the result of his researches, in a treatise on the distribution of electric fluids on a spheroid, based upon Laplace's theory of the problem of the figure of the planets; he establishes, namely, this proposition: that when two electrically charged spheres are placed close to one another, at a certain point nearest the accumulation of opposite electricities, the forces so increase as to come absolutely in contact, and that the fluid, accompanied by a spark, will pass without visible contact.

Before proceeding with the inquiry into the merits of contending theories, it may be advisable to say something of the invention of galvanism; for, though treated as a separate branch of this science by most authors, it forms but a part of the subject I have to deal with, and I, therefore, include it under one heading. In the year 1790, Galvani, Professor of Anatomy at Bologna, accidentally

observed that some frogs, which were lying on his table, became *affected* by the electric discharges from an electric machine in contact with them. This fact excited great attention. Animal magnetism, or electricity, had been, it was supposed, discovered; and had Galvani been as sound a physicist, as he was anatomist, he would have soon satisfied himself that this wonderful phenomena only proved that nerves and muscles were really good conductors of the electric fluid, and hence produced these strange contractions. To Professor Volta, of Pavia, however, science is really indebted for a step in advance made. Two years after the death of Galvani, who died of debility, consequent to the persecution he had undergone at the hands of the French conqueror, Volta constructed the Voltaic pile, which he had the merit of conceiving, upon purely scientific principles, and soon satisfied himself that the energy of action upon organic tissues was owing to the presence of the metallic substances of the Voltaic pile, called into operation by the presence of acids, or even by the action of water.

Volta had, with exquisite skill, invented the electrophorous and electric condenser; and science, armed with these appliances, now made rapid strides in advance. Professor Ohm, of Nüremberg, minutely examined the properties of this new electric fluid, and it may be advisable here to state the three laws he established, deducing them from mathematical formula:—

1st, That the electro-motive force of a voltaic circuit alters, according to the elements, the nature and number, but not the surface of the same.

2nd, That the resistance of the elements is directly proportionate to the distance of the metallic plates, and to the specific resistance of the liquids, and inversely proportional to the surface of the plates in contact with the liquids.

3rd. That the resistance of the connecting wire is directly proportional to its section.

Other men had by this time taken up the subject, and with the names of Ampère and Oersted a new era in the history of electricity presents itself.

In 1820, M. Christian Oersted, of Copenhagen, announced that the conducting wire of a voltaic circuit acted upon a magnetic needle, placed at right angles to the wire. It is said that this glorious discovery was accidental—that the learned professor, whilst making some experiments with a conducting wire, he held a compass at the time in his hand, and observed the needle to move. That immediately repeating the experiment, he established the fact, that the needle deflects at right angles to the wire conducting the electric fluid. No sooner had this become known, than M. Ampère devoted his mind to the laws that regulate the electro-magnetic action, basing his theory upon the law of mutual attraction and repulsion. The beautiful generalisation of principles is so pre-eminently his, that I must, in justice to this great physicist, place his name together with that of Oersted, though undoubtedly Oersted first hit upon the fact of the effect of the electric currents upon the magnetic needle. During the years 1820 and 1821, at almost every meeting of the Academy, M. Ampère propounded fresh views. In these he was met by M. Biot; and it may be instructive to give in outline the points raised by either side during the discussion that then attracted the attention of the scientific world. Voltaic currents, it had been ascertained, attract and repulse one another; and, if situated even in other directions, not parallel, they yet continue to exercise repulsion and attraction, dependent on distance. Now, if in addition to this, we conceive currents to run round the axis of each particle, the means of calculating results comparable with

facts were placed within reach of the physicist. M. Ampère, though facing immense difficulties, conceived the happy idea, that his integrals could be shown to vanish on the whole.* This led to the theory that "any element of the voltaic wire might be resolved into other forces by a theorem resembling the well-known proposition of the parallelogram of forces." The view taken by M. Biot is exceedingly curious, and rests upon the principle known as "the primitive couple" in mechanics. Space will not allow me to go farther into these questions, and I only bring them forward with a view of laying before the reader the leading theories of the day.

I have already alluded to Dr G. S. Ohm,† and the propositions he established, which MM. Paggendorff, Pouillet, and others, have confirmed. The next steps in advance were more in the perfecting of mechanical apparatuses. Schweigger, of Halle, invented the galvanometer, and Mr Wheatstone conceived the *rheostat*—an instrument Professor Jacobi, of St. Petersburg, had likewise constructed. Aided by the galvanometer, Professor Seebeck, of Berlin, made the great discovery of *thermo-electricity* (1822). The next step was that of establishing the law of *diamagnetics*. A current of electricity passed through a spiral of wire becomes identified with the magnet; and by placing a bar of soft iron in the centre of the coil, a magnet is created, and which Professor Faraday found to possess great power of attraction. It was by the aid of this apparatus that Professor Faraday farther ascertained that, besides nickel and cobalt, numerous other substances are magnetic, and that the strange property exists, of steel needles, or iron filings,

* Whewell's Hist. Ind. Science, tom. ii., p. 78.

† Die Galvanische Kette Mathematisch bearbeitet. Berlin, 1827. Ohm.

placing themselves, if free to move, so as to arrange themselves on the axial line; whilst, in diamagnetical bodies, the particles place themselves at right angles—that is, in an equatorial position, perpendicular to the axial line. At the time that these discoveries were being pursued with great vigour and equal success, the attention of others was directed to the improvement of the Voltaic battery itself; and I must mention the names of Cruikshank, Daniells, Grove, and Bunsen, as aiding the scientific world by the valuable inventions they perfected. The most interesting is that of Bunsen, who substituted carbon for platinum. This involved a new principle, and specially merits notice.

M. Arago had in the meantime gained a point: he found that the revolution of a conducting plate, placed near a magnet, affected the magnet. Strange, as Dr. Whewell justly observes, though MM. Herschel, Babbage, and others repeated the experiment, none drifted into the right channel. It was Professor Faraday, who, steadily following up the inquiry into the electro-dynamical induction problem, finally ascertained that the electric action occurred at the time of making and breaking of the contact; and by placing the inducible wire nearer or further the same effects were produced; also that the presence of a piece of soft iron increased this action. By using earth, and revolving the wire, electric action was likewise produced, and thus the great fact of the correlations between electricity and magnetism determined as a truth. The result of Faraday's success may be stated thus*:—"If a wire move so as to cut a magnetic curve, a power is called into action, which tends to urge a magnetic current through the wire; and that if a mass move, so that its parts do not move in the same direction across the magnetic curves, and with the

* Whewell's Hist. Ind. Science, tom. ii., p. 87.

same angular velocity, electrical currents are called into action in the mass."

The theory of *dielectrics*, suggested by Faraday, is opposed to that of *induction;* for whilst the former supposed that the connection was established by *curved lines* through contiguous bodies, or particles in the mass of the intermediate body; the latter theory attributes the action to the attraction of the like fluid to its own side, and repulsion of the opposite fluid, called ordinarily *electric induction.* That distance constitutes an important feature in this theory need hardly be named, and the complex and varied calculations of MM. Coulomb and Poisson fully establish this.

But I must stay my pen: my object is not to furnish a complete history of the progress made, but to lead to the standpoint Dr. Jencken has taken. With this object in view, I will now proceed to give a brief summary of the different theories up to the present day.

Passing the theories of the middle ages, and the quaint ideas under which Aquinas and Cusanus sheltered their ignorance of the actual facts, Descartes was the first to attempt a more systematic generalisation; and though his hypothetical vortices, which he supposed to circulate through the body of the magnet, failed to explain the true cause of the magnetic curves, yet he made a great forward movement, and induced others to grapple with the question.

Æpinus next suggested excess and deficiency of magnetic fluids, "which became dislodged, or accumulated in the ends of the body, by the repulsion of its own particles."* Coulomb, as already mentioned, substituted two fluids for the excess and defect—the *austral* and *boreal*—and then farther established the fact, that it mattered not

* Whewell's Hist. Ind. Science, tom. ii., p. 43.

into how many parts the magnetic bodies were divided, the polar arrangements remained constant. These final parts he designated as *molecules*, and which M. Poisson designates as *magnetic fluids or elements.**

The theory of two fluids M. Dufay accepted, perfecting the views of Wilcke and Brugman. The fluids he called vitreous and resinous, according as they were produced from glass or resin. To him is due the merit of conceiving *statical electricity*, which Poisson farther established and developed.

The next hypothesis to deal with is that of B. Franklin —the frictional electricity; and to him is due the first use of the terms now ordinarily employed—namely, that of negative and positive electricity. But as science grappled more resolutely with the question, the difficulties presented by these theories became insurmountable. The enormous speed at which electricity travels, the action of the Voltaic pile, and the more marvellous translation of electric forces into heat, light, and mechanical motion, nay, even chemical action, became utterly irreconcilable with the theory of a fluid. The points of the electrodes had to be spanned, and many theories have been suggested to overcome this difficulty.

Conduction and induction had to be explained; and to Professor Faraday the merit is due of conceiving that electric induction was the result of the action between the electrised body and the conductor, and by means of lines passing through contiguous particles in the mass of the intermediate body. This theory he substituted for that adopted by Æpinus and Coulomb, that the fluids exert attractive and repulsive force in straight lines at a distance. The question remains, however, an open one, and Professor Tyndall, in his lecture delivered at the Royal Institute of

* Brewster's Magnetism.

Great Britain, January, 1868, admits the difficulty of the great problem. He says—"I have still to learn;" and Grove* tells us that he can only conceive electric induction and conduction possible by the polaric change of the ultimate molecules that are supposed to exist. The phenomena of matter without weight, he says, forces itself upon our attention;† and, to use his own words—"Electric discharges are the necessary results of the sudden subversion of molecular polarisation, or vibratory movement of matter itself." And farther on he says—"I think the phases of thought which physical philosophers have gone through, will be found generally such as I have indicated, and that the gradual accumulation of discoveries which have taken place during the more recent periods, by showing what effects can be produced by dynamical causes alone, is constantly tending to a general dynamic theory, into which that of the imponderable fluids promises ultimately to merge."

The presence of an ethereal fluid is questioned, for the reason that, if this theory be correct, then the more porous, or at least more permeable, bodies should be the best conductors; but this they are not. Air and gas are not, so to speak, stirred by this hypothetical ether, whilst metals are—they conduct; the comminution and fracture of a non-electrical, non-conducting body are inconceivable in the presence of an ether fluid.

The translation of forces, their correlation—I allude especially to electricity producing *motion*—demands notice. The elegant experiment of raising weights by the attraction and repulsion of two pairs of electrised balls, serves to determine the law of the production of a mechanical force evolvable from the Leyden phials.

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* Correlation of Forces. † Ibid. pp. 132, 134, 136.

That *heat* is produced needs hardly repeating. The intensity of the action cannot be measured; there is no substance capable of resisting the effect of electric heat; and the beautiful phenomena of ignited wires, the electric spark, and Voltaic arc, illustrate in the most brilliant form the presence of the resolutive power of electricity translated into heat. Light accompanies these phenomena, and the spectrum of electrical light constitutes a distinct study in itself. Magnetism is also produced, and, finally, chemical affinity. This brings me to the second part of my essay—namely, Magnetism; and I shall deal with its properties before I render my summary of the theory of Dr. Jencken. The reason for reserving the argument upon his treatise being simply this—that he has so blended the two subject matters, that I cannot divide them into distinctive chapters, and hence reserve them for the last.

PART II.—MAGNETISM.

In rendering the following sketch of the history and development of the science of magnetism, I have unhesitatingly taken my material from the works of MM. Bunsen, Whewell, Seebeck, Bio, Arago, and Mrs. Somerville, and shall refer to these authorities only when I quote textually from their works. I mention this, to avoid the trouble of repeated reference.

To those who desire to know the etymological origin of the word magnet, it may be of interest to name that it is derived from the Greek word *μαγνης*, signifying *loadstone;* and tradition says a Greek shepherd of that name first noticed this property by attracting his iron crook. Be this as

it may, it is certain that the knowledge of the magnet dates from remote antiquity, and descended with the Aryan races from the plateaux of Upper Asia to more Western Europe. Homer, Pythagoras, Aristotle, allude to the strange property of a stone attracting iron, and Hippocrates classifies it as a drastic. The Chinese to this day have preserved the rude pristine form of suspending a magnetised needle by a thread. The Arabs were acquainted with the use of the magnet. But, strange to say, no advance was made towards the ascertainment of the laws that determined the direction of the needle until the period of the dawn of our present advance had been ushered in by the changes that were active at the time that Columbus discovered the transatlantic continent; for it was on this memorable voyage of discovery that Columbus (1492) first noticed the deviation from the true north, now known as the variation of the compass.

At this period of our history of the progress of magnetism as a science, we again meet William Gilbert, who comments upon the importance of observing the variation of the needle, in his work entitled "Physiologica Nova." He dwells too with considerable knowledge of the properties of the loadstone upon the deviations of the magnet; and it was Gilbert who first gave the name *pole* to the north and south extremities of the needle. Newton, Huygens, Gregory, Hooke, subsequently had given their attention to the subject, and, in 1683, Dr. Edmund Halley published his work entitled the "Theory of Magnetism." We next come to the works of Graham, Scarella (*"De Magnete"*), and, finally, to Muschenbroek and Hawksbee, who had both at this time instituted numberless experiments with a view of ascertaining the precise laws of the variation of the compass, and had added materially to our knowledge on the subject.

Passing over a long list of names, each meriting mention, I must push forward to the ground taken by M. Coulomb and Professor Hansteen,* and farther lay before the reader the theories of MM. Ampère, Biot, Arago, and Mr. Barlow.

M. Æpinus, of St. Petersburg, in his "*Tentanum Theoria Electricitatis et Magnetismi*" (1759), had established the law, that magnetic fluids repel each other inversely, as the square of the distance; and Halley had suggested that the variations of the needle were attributable to four poles being present, alternating in the intensity of their action. This view Hansteen farther developed; and the lines of intensity of the earth's magnetism, he designated as isodynamical magnetic lines. Two of the four magnetic poles he conceived to be near the North Pole, and two near the South Pole, and constantly moving and at different velocities. He exemplified this by a series of curious experiments; and I may be allowed to mention the remarkable coincidence of the number 432—the most sacred number of the ancient Indians, Babylonians, Greeks, and Egyptians—with the periods of variation of the four poles.† The magnetic axes were conceived by Hansteen, and these he says are produced by the heating and illuminating action of the sun, resulting in a magnetic tension producing electric phenomena.

The interest awakened by these writings induced the Norwegian Storthing to vote a fund for the defraying of the expenses of a voyage of discovery to Siberia. This

* Untersuchungen über den Magnetismus der Esde, 1817.

† For farther particulars of this strange coincidence, Brewster's Magnetism, pp. 188, 189, and 190, must be consulted. The mean distance of the earth from the sun is 216 radii of the sun; that of the moon 216 radii of the moon, and $60 \times 432 = 25920$: the smaller number divisible by all the four periods. 432,000 years is the period of the first breathing of Bramah.

resulted in the determining of a magnetic region in the north-east of this great continent. The inquiry into the laws of magnetic intensity and variation were now studied with vigour, and Baron Humboldt induced the Imperial Government of Russia to establish magnetic observations in different parts of the realm. This example was followed by the Governments of Berlin, Paris, and Vienna. The British Government likewise granted funds for magnetic observatories at home and at the Cape of Good Hope.

The result of numberless observations, in which MM. Quetelet, Fox, Forbes, Bache, Colonel Sabine, and other eminent men took part, are traced in the *isodynamic, isogonal, isoclinal* curves of the magnetic charts of the earth, which mark the *intensity* of the magnetic force—*declination,* or *variation* of the needle, and *inclination,* or *dip.*

These observations have led to the determining of the annual and diurnal changes, or variation of the needle, which are, as M. Cassini observes, independent of the progressive change in the declination of the needle. Between January and April, the western declination increases; from April to July, it diminishes; between the vernal equinox and the summer solstice, the needle retrogrades easterly; during the other nine months, westerly.

The diurnal movements of the needle point to a law of repulsion akin to that of the repulsion of equal poles of the electrodes. M. Canton tells us that at sunrise the needle swerves westwardly, "as if it were avoiding the solar influence," attaining a maximum deviation towards noon, and returning eastwardly from that time, until ten or eleven in the evening. Do not these facts speak unmistakably of solar power affecting and, as I maintain, producing magnetism? M. Hansteen attributes to sun power the source of all living activity. He says:—"For these

reasons, it appears most natural to seek their origin in the sun, the source of all living activity, and our conjecture gains probability from the preceding remarks on the daily oscillation of the needle. Upon this principle, the sun may be conceived as possessing one or more magnetic axes, which, by distributing the force, occasion a magnetic difference in the earth."*

Canton likewise held these views; and Professor Seebeck proved that the application of heat to a circuit composed of two metals will produce the magnetic effects. Mr. Barlow, in the meantime, had by induction caused electricity to pass through the wires of his artificial globe.

Captain Duperrey ascertained that the curvatures of the isothermal and the isodynamic lines nearly agreed; and from this fact, and other observations, he concluded that heat had an important function in producing magnetism.

Opposed to these theories are those of Sir David Brewster and Mr. Dalton. Their hypothesis is, that the iron particles of the earth induce magnetism, which in fact has no independent existence—that the true cause is that of electricity, producing magnetic currents; and Professor Barlow published (1831) a paper, "On the probable Electric Origin of all the Phenomena of Terrestrial Magnetism." The effects of the aurora borealis upon the needle are attributed to the presence of ferruginous particles, which radiate from the aurora in *beams*. "The aurora borealis," says Dr. Dalton, "I conceive to be a magnetic phenomenon, and its beams governed by the earth's magnetism." The atmosphere, it is supposed, is surcharged with ferruginous vapour; and that this is true has been endeavoured to be proven from the fact that elevation of position, according to the observations of MM. Gay, Lussac, and

* Brewster's Magnetism, pp. 264, 265.

Biot, does not diminish the intensity of the magnetic action. Mr. Henwood actually found the action the same 950 feet below the level of the sea. M. Quetelet states that the intensity increases in ascending the Col de Balme, near Geneva.

Sir David Brewster established the highly important fact, that two poles of maximum cold exist in our northern hemisphere, which poles coincide with the magnetic poles; and that the magnetic and isothermal lines more or less coincide, surrounding and enclosing the magnetic poles; and *mutatis mutandis*, the temperature of the globe could thus be ascertained.

I have thus far crowded in facts and theories, without even a word of introductory prelude, and necessarily, in my desire to condense, had to give my data in the baldest form; but this has been unavoidable, from the enormous mass of material which the researches of these great men have placed before me. I will now conclude with M. Gauss' theory of terrestrial magnetism (1839). He ascertained that the fixing of one pole was erroneous—that two, four, or more existed, according to the laws of ordinary magnetic phenomena—that magnetism is distributed equally throughout the mass of the earth, in an unknown manner. He therefore assumes a function V, well known to astronomers, which Dr. Whewell calls the "integral proximity" of the attracting mass. To state briefly the result of M. Gauss' calculations: he assumes eight places to calculate his twenty-four co-efficients from, which again give him ninety-one places for magnetic elements (intensity, variation, and dip). These calculations coincided to a marvellous degree with actual observation — a true point, representing a pole, becoming converted into a magnetic region, like the Siberian region, where the needle converges. One result, however, was unexpected: M. Gauss

proved, that though the earth is equally permeated with magnetism, the currents tend to *two* poles, vertical to one another.

The theories of MM. Nobili and Melloni upon electric thermology, and the delicate galvanometer they employed in verifying the temperature of electric currents through plates of antimony and bismuth, the thermo-electric battery of M. Becquerel, who farther established the relation between heat and electricity, bring me to the consideration of the dynamic property of magnetism—its static, directive character — which Professor Faraday proved whilst making the important discovery, that electricity produces magnetism, and to which I have already alluded. Magnetism produces electricity at right angles to the lines of direction of the poles; this again produces heat, light, and chemical affinity, and finally motion.

But there are other properties of magnetism—the diamagnetic character noticed by Professor Faraday; its effect on light, heat, and chemical affinity; and, farther, the truly beautiful experiment of Professor Faraday, of deflecting a ray of light by magnetism, point to its deeper-seated powers. Magnetism, according to Mr. Grove, is dynamic during its increment and decrement. It is in this dynamic state, this state of change, that the forces of electricity and their accompaniments, heat and light, are developed; and it is with pleasure I notice the idea put forward, of the non-existence of a constant, primary, initial quantity. No such condition exists in nature, and the term can be only conventionally used. The law stated by Mr. Grove approaches nearer the truth. He says—"A molecular change in the arrangement of the matter subjected to magnetism takes place." This molecular change, I contend, is produced by the constant inflow of the all-supplying, all-permeating ether influx, which is constantly centralised, mediatingly so, by

the presence of the molecules of matter, which molecules again may be resolved into those centres of force spoken of by M. Boscovich. The universality of a common ether is a grave theoretical error; but an ether state—I use this term for the want of a word more expressive of my meaning—supplying the final centres, or molecules, or points of force, and centralised in these whilst supplying them, I believe, explains many of the difficulties hitherto combated by physicists.

Electricity is nought but the non-assimilated inflowing stream of the supplying ether wave from the intro-world—non-assimilated, because the body electrised has been disturbed in its centrality by friction, by contact, by the action of acids: hence this inflow is non-mediated, becomes accumulated, and, retaining the primary dual character of its origin—for all forces are dual in their inception—surcharge, followed by discharge into the opposite pole, ensues, marking the condition of the influx, which, now non-mediated, swells up into a wave point, which becomes released at the points of the electrodes from its state of tension. The final span of space at the terminal points being bridged over, not by dielectrics, as Professor Faraday conceives to be the case, by the converging molecules passing from one point to the other, but by the presence of this ether inflow, this imponderable incoming stream, which envelops and permeates all materiality, changing from the imponderable, by centralisation, into form and matter, in never-ending transmutations. If I may be allowed to hazard the expression of an idea, the inflowing ether stream is essentially concentric; hence its expansive motory property, whenever checked, accumulated; once transformed into matter, its resolution is mediated by the gradual process of decay, which is again an act of mediation. This resolution, if accelerated, causes explosion; and

explosion is only a form of that return to the primary ether condition, abnormally conditioned; hence followed by disturbance, suddenness of explosion—time being an essential element in the operation.

I have thus far given in outline the theories of the writers on these great questions, accompanied by such statements of the facts as became absolutely necessary to illustrate the propositions I have endeavoured to explain. All that now remains, is to place saliently before the reader the theories of Dr. Jencken. The comparison of his views with those of Hansteen, Gauss, Æpinus, Arago, Biot, Faraday, Grove, and Brewster, will be rendered intelligible by the sketch given in the foregoing pages.

The inflowing solar and telluric powers, says Dr. Jencken—which cannot be assimilated, owing to the disturbance caused by friction, contact, the presence of acids —produce electricity. Hence, electricity carries within itself the solaric, telluric forces, and also the character of the substance acted upon.

Electricity, galvanism, magnetism, though akin in their characteristics, are, nevertheless, essentially different, each representative of distinct, deeper-seated, more primary forces. The great fundamental dualism of all forms of nature, of all the operations of creation, manifests itself in these primary forces, as negative and positive, rest and motion, static and motory forces. Friction produces negative and positive states; for the solaric principle enters, in fuller inflow of power, the instant the cohesion of the telluric principle is lessened by friction. This again results in accumulation of the telluric, and ultimates in the state known as electric tension.

I have given these definitions of electric forces, as marking the distinct views taken by Dr. Jencken. *Being* and *Becoming to Be* are the great primary creative princi-

ples, and in all the operations of nature, rest and motion, central and peripheral, repeat, in endless modifications of form, this all-present principle of life and creation.

The next question is, what is the principle of conduction ?—the great problem which all have endeavoured to understand. Dr. Jencken tells us, that metals, like all other bodies, constantly produce electricity, and that the outflow from these substances, as in all others, is constant, but mediated. Now, in the act of conduction, the inflow is not assimilated, but repelled from point to point. The less this assimilation, as is the case in metals, the greater the conductive power. Metals contain, however, the telluric element primarily as their own, hence, are at once affected; but there the effect terminates, repulsion follows.

The reason why gases, for instance, do not convey, conduct electricity, is simply this—that they do not present points of concentrated telluric powers, like metals and other conducting media. Electric phenomena are observable in every act of combination, in respiration, in every movement and contraction of organic tissues; for throughout, this inflow of solaric and telluric forces accumulate, unless they be assimilated, transformed; and so true is this law, that arrest, check—such, for instance, as the resistance of a sheet of paper to an electric, galvanic spark—completely dissipates its force, the reason being that the transmutation is completed, the force converted into a power, non-operative, in the former phase.

Whatever disturbs the supplying inflow of the primary powers produces electricity; the air itself is electric, every plant and substance is electric. The enormous celerity of the transmission of the electric fluid (I use the term conventionally) only proves the immense power of assimilation of this inflowing stream at every and each point of the conducting medium; and at this stage Dr. Jencken

and Mr. Grove agree as to the molecular action sublying the electric phenomena.

Gravitation, magnetism, and electricity are all three only forms of one great principle of elementary force—gravitation representing the inflow of elementary forces towards the sun; the *intro-existing forces*—as I have designated the great supplying influx—explain, in their progress and manifestation, the phenomena to which I have devoted these pages.

Before concluding, one word more upon the imponderable character of these physical phenomena, upon which Mr. Grove dwells with such vigour and clearness. The inflowing forces bordering on, and strictly connected with, the materiality that surrounds us are, nevertheless, distinct, belong to a certain state of elementary conditions—we cannot measure by gravitation, cannot span by space, nor calculate in points of time; hence their presence, their disappearance, their suddenness, boundless swiftness, and all-permeative presence and constant recurrency. Their might and span none will deny, none can question. Sun power, for instance, I maintain, is translated into electricity, repelling the earth globe forward into space. The globe cannot, however, stir from its place, held back by the force of attraction; tangential action (at right angles to the opposite direction of the two forces) follows, and revolution and rotation from this. I allude to this theory, which I have developed in a separate treatise, in confirmation of the boundless energy of the inner forces, that uphold this world in space, nourish, sustain it.

ELECTRICITY AND MAGNETISM.

BY

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TRANSLATED FROM THE GERMAN

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ELECTRICITY AND MAGNETISM.

MATTER and power must never be regarded as distinct in nature: they stand related to each other as positive to negative, as striving to detention, as transition to plastic formation. The same power which sets a body in motion can also arrest it in this motion; the striving power, when in a state of detention, is matter—*i.e.*, solidity, as in polarity. No power in existence is devoid of reaction. This is an inherent property, and all polarity springs from, and is related to, the eternal primary polarity, which alone, free born from the Divine Source, could render the world of individual creation possible. In no place and in no direction can absolute stagnation of the striving power prevail —transition and interchange, reception and combination, are in continual operation.

Ultimate elements, or any ultimate primitive states of a power, can no more be admitted than ultimate atoms. God's creation is infinite; the relations of every natural product, both in the ascending and descending scale, are infinitely manifold; and the subtlest ether even must contain within it various conditions and effects of power, inferring yet remoter elements. Atoms are at most only the ultimate points that can be imagined of the general action and reaction of natural powers. But as every species of matter being created is only a certain state or

condition of power, perpetually operated upon and infinitely metamorphosed by incessant influx and reflux, to speak of really ultimate effects of power is as much beyond possibility as to imagine an ultimate divisibility of the particles of matter. All we can speak of is the greater or lesser interruption to the active striving of a power, the closer or more separated points of operation.

Every element—light, air, and even electricity—is only a more diffused and general state of existence of power in such investures, and which stands opposed to its concentrated state. Predominant expansion is the characteristic of an element, even though frequently accompanied by an excited tendency to concentration. One and the same elementary state of different powers, under the forms of light and air, may exist, without our being able to distinguish the difference; so that we may imagine that we always perceive the same in the light and air.

But how manifold are the species of air co-existent in the atmosphere; and has not each body its own peculiar light, exhibited in its varying lustre and form? and are we not aware that the electric power of the spark from the cloud even deposits a metallic dust, that the solar beam is fraught with an acidulating property, that light is metamorphosed into moisture, water, and even into solid matter, and that by the galvanic process we are enabled to decompose sulphuric acid into its constituent parts—viz., sulphur, oxygen? Thus all powers and all bodies have their elementary states, and every element contains various ethers, and develops itself gradually in all its peculiar properties, as different individual products. When the striving condition predominates in a power, the supplying influx and the efflux operate in such rapid transitions that we are *no longer able to distinguish* the *slight* and *transitory* stagnation of each point of existence. There is in this case also

a *deficiency* of permanent opposition of such power to other powers, *each* determines the movement of the others, and the universal continual flow of the primitive power obtains the preponderance over plastic individualisation. We cannot, then, duly recognise powers in their state of stagnation and solidity, but only in their states of active operation, and then we term them elements. The general character of striving then prevails; all that may be more individually marked in each operation is obliged to yield place —external active relation acquires the mastery, and the general striving condition in all provides for each the nearest related investure, of the most volatile nature, often traversed by other streams of power, and in the most rapid metamorphoses incessantly reproduced. A power can only become a solid body by means of an established opposite polarity. Where the pole of active striving breaks through the balance, there the streaming undulations (although always necessarily coexistent) are only feebly marked as corporeal investure.

Both in primary formation and ultimate solution all products bear a strong resemblance to each other, because the general supplying power predominates in the striving sphere; only incipient points of contact are produced, and no further grade of formation becomes established, because the continually fresh supplying influx perpetually recommences the primary corporeal formation in the shape of an element.

Primary contra-position or polarity, indeed, is pronounced throughout as the highest and most universal law of nature. Eternal divine being, and eternal divine progressive growth in all infinitude, appears the most manifest truth, the most purely intelligent thought, that can result from the investigations of the contemplative spirit of man. Free contra-position in the sphere of divine

perfection must embrace the total realm of manifoldness, and thence originates an universal striving upwards from *all directions*, and in variously marked degrees of elevation. Power is a striving energy, and no striving with attained aim can be imagined without an opposition striving; and thus power bears within it its negative property, as being and becoming *ad infinitum*. Direction and contra-direction is the most simple designation for such primary polarity. As rapid metamorphosis and plastic formation, we encounter it in nature's realm, and whatever elementary appearance may be assumed, such polarity is infallibly inherent. Light develops itself into the formation of colour, arrested by its own negative property (obscuration) as contra-action; in stagnation it exhibits cold, in opposition to the expansion of warmth; hydrogen and oxygen, in their co-operation, combine as water, &c.

The negative pole in all cases induces concentration, obstructed striving, causes accumulation; the modulations of the supplying influx follow *closer*, are *less interrupted* by any other operating power, and are retarded by the waves of the opposite stream, which cause a retrogression, oscillation. But here also opposites *combine;* all that is positive and negative inherent in a power receives from without the supplying influx from all polar directions. The positive tendency is by the opposite pole turned into a retrogressive course, as is also the negative in the same manner; the parallel stream onwards, but sidewards, is the result, and *this* marks combination and *unity*. Whatever receives its supply from the *same* source, and strives in a parallel direction, is closely *related*, and connected in as far as their finite career permits.

Divine power must work itself a free path in every direction, and this is effected by the contra-polarity, which, communicating itself, elicits the positive in the negative,

and *vice versa.* Universal manifoldness gives birth to an infinite possibility of direction; and the greater the number of parallel tendencies developed, and the fewer the counter-operations which intervene, the more elevated and perfect is the grade of the individual product.

Contra-position, in its most ideal sense, is the change of the infinite to the finite; solution, or freeing again, on the contrary, and elevation, is the change or return of the finite to the infinite. The acme of contra-position exhibits itself in a finite sense only where the counterpoised accumulation reaches such a point that the power accumulated in repression renders the negative stream again predominant, as having now become the stronger. All accumulation, however, is a closer succession of formed waves from the positive and negative sides. If the restraining pole be suddenly removed, explosion is the result; the efflux preponderates, and every wave bound by the negative pole, and all those succeeding within a narrow limit, suddenly find issue; the effluent power acquires greater force in consequence of such impulses, and, therefore, communicates itself in more rapidly succeeding waves to those bodies with which it comes in contact. This law must be borne in mind as a leading principle in all cases of explosion, whether of electricity, of air, of steam, or of gunpowder.

Rest and motion exhibit a perfectly polar relation. Every impulse communicates to the body at rest one-half of its motion, and retains the other. Equally strong impulses, opposed to each other, produce rest on both sides; and all communicated impulses, in unequal proportions, proceed in perfect strictness, according to the rule for what is imparted, and for the proportionate loss during communication. Thus in each body, sometimes the positive tendency, as communicated impulse, prevails;

and sometimes the negative, as receptive of power. Difference of direction is here clearly the distinguishing mark of all the various forms of polarity. The only question is, whether an actual communication or supply takes place, or merely an excitation of the existing power.

Manifold and most various powers stream from all sides in supply upon every point of creation. Everything in existence, whether the stone, the animal, the bone, or the nerve, is continually *supported* and *renewed*. Even the great mass of blood that streams through the heart every hour, proves that a change takes place in the whole corporeal mass with every pulsation. Even the diamond would suffer decomposition, were it not supported by telluric, planetaric, and solaric power, and were not these influences in *perpetual renewal*. Without a supply of centripetal power, no cohesion could take place; and without a supply of centrifugal power, no proportionate contra-pole, no corporeal formation, no possibility of motion, could ensue. The internal cavities of every precious stone, when observed through the most powerful microscopes, are found to contain clear and even different fluids. The different fluids (the one highly expansive, the other very dense) remain unmixed, though in close contact, until set in motion, within their little laboratories, by an increased temperature. Here the supply is furnished, and the transformation of powers from air and moisture to the solid state is negotiated. Our feeble eye, indeed, is unable to follow such transitions, or even to perceive the working matter in the changing hair and nail—these seem always to us the same objects, even while undergoing perpetual renewal. Everything, both solid and fluid, exists in ever-fluctuating transition. Supply, assimilation, and efflux, incessantly support each other; and such recognisance of the primary laws can only guide us

through the wonders of nature in general, as well as through the phenomena of electricity and magnetism, more immediately under discussion.

By friction of the glass plate, the cohesion of its surface is disturbed, the assimilation of the supplying stream can no longer be perfectly effected. This issues forth, though slightly impregnated with the character of the vitreous power, yet more as a general *supplying element.* Its polarity consists in a solar and telluric combination of power —the solar (positive) direction is impulsive striving, the telluric (negative) tendency is retardation and reception. Such solar and telluric unity exhibits itself more clearly to us as polarity, under the form of hydrogen (carbon and sulphur also) and oxygen, alkali and acids. The muscular and reproductive systems stand in similar polarity—they also discharge themselves into the nervous system, while this again displays its polarity in the ganglions and the spinal marrow, and its higher union in the brain. The electricity of glass and resin, termed positive and negative, represents the solar and telluric elementary co-operation. The solar power, indeed, streams from all sides of the rotating sphere into the centre; the telluric power streams from the centre outwards. But both are in their earliest primitive relation, each *inherent* in, and co-operating with the other. Thus the telluric power streams into the solaric as a *replenishing,* supplying influx to the telluric property inherent in the polaric, and *vice versa.* In all terrestrial productions and elements, both are found, and absolutely belong to each other. The solar positive stream can only find entrance where there is a deficiency in its supply, where the efflux is too preponderant; and the same takes place with the negative where there is a want of the negative stream—*i.e.,* where the efflux of the positive is too rapid. The supplying stream, however, is a striving action,

a continual impulse, an overcoming of the separating oppositions and counteractions, and thus does electricity give birth to attraction. In many bodies, the telluric influx (the hydrogenous principle) predominates, *e.g.*, in the resinous; in many the solar (oxygenous principle), as in glass. Where either pole preponderates—the solar, for instance—it then stands opposed to the whole of the telluric supplying stream, directed towards the same object. By this means, an accumulation of the telluric stream prevails around the object, and this immediately penetrates wherever any foreign power assails the assimilation, and impedes the approach of the solar influx.

The ultimate foundation of the accumulation, and of the supply of the opposed influences, refers itself to the contra-polarity with which every power must be originally imbued from the divine source; for the intrinsic being remains, as rest opposed to motion, and exercises an equal force only in alternating predominance. A state of being is the inherent property of every power—this constitutes its universal relation, and this strives against its progressive motion. The plastic influence of multifold unity is diminished during the prevalence of the striving onwards, and this freeing energy is weakened during the preponderant influence of universal manifoldness. Both are supported by equal power, and each *accumulates itself* during the predominance of the other, and its subsequent *irruption* is attraction of that other, in consequence of increased supply. Every power, therefore, contains in its intrinsic nature all its external relations. It may, consequently, well be said that it attracts the contrary pole, because the more rapid onward stream within it sets in motion its whole sphere externally at all points. The most comprehensive elucidation of electricity is furnished by the axiom, that all bodies must be continually supplied

by solar and telluric powers, and also by many others in addition, especially such as are contained in the former, and which, during subsequent development, separate themselves, and assume an individual formation. One supply conditions the other, and one supply completed, conditions the increased attraction of the other. Thus every stroke of a billiard ball against the side of a table, every ray of light upon a polished surface, exhibits a supply of power, which conditions a negative accumulation in exact proportion to its positive accomplished result, and thence it arises that the reflected ray takes an exactly contrary direction onwards to that of its incidence. The general relation inherent in each body constitutes originally its *vis inertia;* the preponderance of any one of the powers streaming in, conditions motion and the gradual overcoming of oppositions, until these accumulate anew in the supply, and rest ensues. Terrestrial attraction, gravitation, is solar supply; solar attraction, planetaric supply; and, mediated by the latter, the cosmic influences which supply the sun. When positive electricity is elicited in the glass plate by friction, negative is manifested in the rubber. Equalisation is the universal law of nature, as the result of polar action. Wherever excitable substances are rubbed together—*e.g.*, silk and the glass cylinder, rough and polished glass, black and white silk—positive electricity is produced in the former, and negative in the latter. The solar stream penetrates into the body in vicinity, and represses the telluric supply. This collects itself, and acquires strength by concentration during its accumulation; for the striving power, being conditioned by polarity, increases again as the opposite pole to rest, so long as this continues to hold it in check. The negative supply thus strengthened, leads the positive power sidewards (its direction inclines more negatively), and thus arises at the same time

increased influx, in consequence of the acceleration of the onwards stream.

In the extremest positive state, however, the negative also exists, as the *repressed pole;* and this accounts for the frequent alternation of the polarity when electric bodies are rubbed together—negative with negative, and even positive with positive—where one and the same body exhibits sometimes a positive and sometimes a negative polarity. Feathers with wood and with paper, and paper with silk, become positively electric.

All electricity, as well as galvanism and magnetism, is an irruption of the general telluric element (from the cosmic as well as the planetaric and solaric combined together); it undulates perpetually between the oscillation up and downwards from the sun and from the earth. The precursory stream is easily excited everywhere, a disturbance of the cohesion occurs; it enters then immediately upon a new course of formation, commencing with the phenomenon of light, of explosions also, warmth, and the generation of gas. Whatever assails the structure of a metal—*e.g.*, acids, salts—and even contact between two metals in which an opposite polarity prevails, excites the stronger elementary stream. The vicinity of the negative metal presents a more closely related sphere to the efflux of the positive, or its power is accumulated by previous obstruction, and the more copious reception which consequently ensues. The newly arisen stream, meanwhile, rushes more forcibly out of both into a third medium, to enter upon a new course of formation. This medium offers less resistance to such new formation than the solid and more isolated metallic structure. A similar elementary stream proceeds from the magnet, because there the metallic formation has not been completely effected. Hammering metals produces the same result, as well as rubbing

iron with a magnet. The too copious influx renders the assimilation difficult; and in consequence of this changed influx remaining as supply, supported by telluric operation, the magnet property is kept up. The increased influx arrests the assimilation, and by such stagnation conditions an accumulation of the general supply; upon this ensues an increased striving in the latter, and again renewed disturbance of the assimilation, and thence arises the permanence of the magnetic action.

The strongest opposition between the solar and telluric influences must take place under the line and at the poles, and combination and conformation of the elements from both sides must also originate there. Magnetic bodies abounding with the unassimilated stream must receive such motory direction. Positively electric bodies produce the negative state in those near them, and these again the positive in their own vicinity. The predominance of the solar influence creates stagnation, accumulation, and consequently increased activity in the negative circumjacent sphere; that of the negative, on the contrary, causes stagnation, accumulation, and striving in the positive current. Thus sealing wax subsequently repels the particle of paper which it had previously attracted. The influx was a solarically excited supply, by means of the repression of the telluric in the sealing wax; this now causes telluric stagnation, and consequently increased negative irruption and influx into the particle of paper, which then falls away; or else a negative surplus is generated in the paper, which strives towards that simultaneously formed in the resin, and changes the bent of the direction. Positive poles repel each other, as do also the negative; by the *flexion* of the *direction* of their current they create their own polarity. Where positive and negative poles strive towards each other, it is not merely that each advances to

supply the other's deficiency, but it takes place also where rest and stagnation prevails, where, therefore, motion is not opposed to motion: what is related flies together, and out of four poles two are formed, as an elementary combination in unity, Two currents in the sphere of motion, however, each can only act upon the quiescent pole of the other, and must, therefore, produce retardation; and if the striving energy break through, there is a negative turn aside in the direction. In the first case solar and telluric polarity takes place, in the second (when poles of the same denomination are opposed) a polarity of direction and motion, as one *more nearly approaching* the primitive polarity. No less important is the conduction of electricity and its abode in metals. Electricity is, indeed, present in all bodies; but it streams forth again from each, individually modified, its relations towards an infinitude of other powers are changed, here or there more excited, or more combined. Electricity, galvanism, and mechanism, therefore, exhibit themselves as closely related operations of nature, but each bears its peculiar character inherent in it. In metals the mass is bound by a stronger polarity, and by a denser accumulation of the undulating influx; concentration consequently prevails, presenting a closer formation of waves, with less foreign intervening operation.

The telluric supply must be more potent towards the metals, and every inferior current is determined in its movement by the superior. Thus the metals evince most attraction for electricity, and yet retain it unassimilated. The copious supply within them has overcome the manifold foreign intervening action (*i.e.*, is assimilated); but the lesser new (electric) influx has as yet these periods to pass through, or even may be unable to accomplish them, because the individuality of the metal only permits a

specific degree of repletion. The great stream thus retains the lesser within its sphere of direction; but the opposite tendency is at the same time so stimulated, that wherever a fresh efflux offers itself in another direction (for every presented body has also its supply), it then becomes determined by this, repulsed (negatively determined in the striving direction), by the fulness of stagnation in the metal, and attracted by the body presented, whose continually fresh efflux conditions also a perpetually fresh influx.

Some bodies both receive and assimilate the spark, and this prevents its conduction. Some do not receive it at all, because they have already appropriated so many other influences of a more highly developed terrestrial nature than the electric telluric influx—such bodies are wood, resin, and also glass. These, however, are the more easily electrically excited, because the elementary current within them is not so closely bound, but has its abode there as primary supply, ready for higher transformation, in products where the solar and telluric influences are interwoven in a superior grade. In these non-conductors, therefore, either the accumulated supply is too slackly bound, which occasions them to act repulsively, their current flowing more outwardly than inwardly, and they being then more imperfect productions; or they are higher formations, possessing other nutrifying streams, and retaining the inferior (yet in their elementary state) loosely within them, ready for gradual transformation; the elementary supply does not in such case stream towards them in so elementary a condition.

All very combustible substances (among which must be classed the electric) are in a state of telluric elementary accumulation, without adequate assimilation; therefore, the more powerful stream proceeds rather from than

towards them, and upon this rests their slight conductile capacity.

All combustion, as well as phorphorescence, and even respiration itself, stands in close affinity to electric operation. A body comes in contact with the augmented influx of elementary free power, and this influx, supported by some potent external source, continues to exalt itself as long as it remains unimpeded by any intervening power. It communicates itself from one part of the body to another, causes everywhere obstruction to the assimilation, and therefore occasions an increased efflux of the elementary nutritive supply, which receives the oxygen as the positive to its negative pole, and enters upon a new formation in the development of light and heat. The residue of the burnt body is an oxyd—*i.e.*, a newly arisen, more primary product from the elementary stream, already assuming a more solid form—*i.e.*, coal. In this case a formation of matter also takes place, proceeding from the closer undulations and lesser intervention, and, consequently, more complete repulsion of the foreign influx; and this is the basis of all individualisation.

Every electric and magnetic phenomenon is an elementary (solar telluric) irruption of power, in renewed primary plastic striving (effected by the increase of the inward against the outward striving, from which results more concentration, more undulating accumulation). In animal magnetism also the same principle of operation prevails, as well as in all the more potent pharmaceutical bodies, especially the poisonous, narcotic, or metallic oxyds, and poisonous animal substances. The striving towards concentration appears as the negative plastic tendency, in opposition to the striving outwards, which is a dispersion effected by the foreign relations, which become valid against the chief tendency and course of direction. The

diversity in the course of direction, and the diversity in the combination of the manifold directions into parallels, conditions the variety in the multifold irruptions of the same power; for in the freeing of any one individual plastic energy, this freeing operation (formation) is only gradually effected by every additional foreign undulation being mediated by the one in its vicinity. Every copious efflux, like that towards the metals, conditions the direction of the lower currents to and fro with itself, and this motion retains the latter within the sphere of such stronger direction of power, even without assimilation, until a renewed supply of motion from some other stream determines its abduction. Upon this principle, a clearer illustration may be obtained of all magnetic, electric, and numerous other phenomena of nature.

The entire dispersion of the galvanic power—where even in the strongest spark it is conducted upon a piece of paper—is certainly extraordinary. The feeblest external opposition may indeed be able to excite the special contrary pole of the strongest stream of power to assume an opposite direction (for the capability of every direction is inherent in every power, because it stands in universal relation, and elevates itself out of this universal relation). But the paper, by its elasticity, conditions a transient abode, time sufficient for the accumulation of the negative current; and it stands as a combustible body in a middle grade (not too rapidly combustible), where the combustion is longer retarded than in hair, resin, cotton, &c. The influence of the paper, therefore, provokes a continual plastic striving in the elementary power to pass from the first elementary shape into the following natural productions—viz., air or moisture, possibly—and this occasions the dispersion of the concentration of the galvanic spark.

A body presented to the conductor, discharges it of the

electric accumulation—*i.e.*, furnishes the unassimilated influx of the element within the metal with a supply of its own influx and efflux, which now operates more decidedly, because the condition of non-assimilation creates repulsion, a negative (changed) direction of the striving power. Moisture is a strong conductor, because it offers the nearest plastic state of transformation to the elementary power, and oscillates in an extensive range of influx and efflux. The electric fluid enters the conductor most thoroughly when a round body is presented, because, in this case, the metallic stream penetrates more generally, and draws with it the inferior; while the point, on the contrary, discharges the stream more easily, it being then less checked by the metallic mass. Electric light is the primary form of appearance of the elementary plastic striving power, which enables it to flow into organised bodies. This augmented influx the eye recognises (first, organic consciousness) as light, and the ear as sound; the other senses are also sensible of it, in taste, smell, and touch.

The rapidity of electric transmission (any number of persons placed in contact, feel at the same moment a shock communicated to any one of them) is related to that of sound, and also to that of light. It is not so much a communication as an incitation which here takes place; the slightest supply at any one point conditions an instantaneous accumulation of the supplying current everywhere present, creates a sensation of such accumulation, and of its solution everywhere throughout the organic sphere. Naturally, any body in which this accumulation can only slightly, or not at all, be induced, immediately obstructs the transmission. The sensation is a powerful vibration, with an instantly fresh commencing stagnation or consolidation, contraction. This arises entirely from a repulsion

of the foreign material, and a closer position of the related (and scarcely interrupted) undulations.

Expansion is outwards direction, conditioned by a stronger current from without. More intervening powers and undulations are influential, and the foreign material associates itself hereto, whereas, in contraction, it is repulsed. The primitive elementary operation, striving and contra-striving, exhibits itself in terrestrial nature as the solar and telluric principle, always combined, sometimes positively and sometimes negatively predominant. Excess of the influx from the solar pole gives summer heat; excess of the telluric opposition, cold. The negative tendency changes the instreaming direction of the positive to the negative, and repulses all foreign material; the undulations become closer, and thus consolidation ensues. Excess in the solar supply is constantly generating itself during summer, chiefly in the equatorial regions; then, indeed, the telluric pole recedes, but accumulates itself as retarded pressure onwards, and, being more individually repelled, does not assume a permanent checked station as in winter, but breaks forth suddenly and momentarily from its isolated compressure, and, in such cases, the electric spark bursts forth even from the surface of the earth. In the cloud, however, a new intermediate product is generated out of the excess. (A similar excess of the fresh plastic energy probably consolidated itself around Saturn, and gave birth to his ring.) The stratum of clouds which surrounds the terrestrial globe is such a fresh creation. The lightning flash, indeed, contains even metallic dust, sulphur, coal; and ærolites are similar productions. The superior plastic tendency, however, conditions the inferior, impels this to concentration, and to follow its course, as elementary stream towards the earth. The concentrated current of the solar telluric clement is penetrative and

most forcibly disturbing in the lightning flash. In the cloud already more solid formation takes place—first vapour, then drop-fluidity and hailstones. So far the new planetaric construction is able to maintain itself, then it follows the current of solution (by means of the positive influence), the superior stream to the earth. A due proportion of the negative influence has arisen in the clouds, which opposes itself to the solar influx, and transforms this to its negative state, with stagnatory opposition and compactness in the undulations. Heat and cold are likewise polaric currents of the same elementary power that prevails in electricity and magnetism. There exists even a terrestrial heat, such as predominates in England in cold seasons, and frequently in volcanic islands—a sultry air, such as is found chiefly in mountain caverns, and in the depths of the earth. The telluric pole then becomes preponderant; the solar brings stagnation, the negative consolidating state; while, on the contrary, the terrestrial element operates expansively. The proportionate relation of the direction always determines the negative and positive—whatever overcomes stagnation is positive, whatever holds back the striving energy, negative. Where this opposition increases in its sphere of striving, until it has attained an equal degree of power with the positive pole, the most perfect state of consolidation prevails. The freed issue is effected either by overcoming one of the poles, or by the union of both in a parallel course of current; the power then operates farther in a fuller state of existence, more richly provided with that intrinsic contra-polarity, which, however, originally prevails in all.

All evaporation produces cold, with the air streams in a supply to the volatile substance, which inclines to gaseous production (alcohol, vinegar, ether). The body which comes in contact with it offers resistance, does not follow

the stream of expansion; therefore, causing negative accumulation and consolidation, it produces cold. Electricity, especially in the form of galvanism, acts decomposingly upon many substances, produces heat and combustion from whencesoever the spark may have proceeded, even from ice itself, as the irruption of the freed or accumulated element. Electricity also produces phosphorescence—*e.g.*, upon marble; it deprives camphor of its scent, it melts gold, and burns it in a coloured form into glass. Transformation to the elementary stream is everywhere the result. The electric spark renders the striving energy predominant over the stagnation; it is itself connected with the more powerful supply, and as it disperses itself, it moves the accumulated undulations of the more solid body with it in manifold direction—it dissolves them, or stimulates the freeing tendency, which already preponderated as in the marble, to phosphorescence; or prevents the change to gas, as in the camphor, by a too copious supply of the stronger elementary influence, which then immediately conditions a more elementary form than gas can offer. Like every other predominant elementary influence, electricity when unmediated operates too violently upon the deeper organs, especially upon the nerves. In the nerves manifold powers, organically combined, have risen to their *highest* unity, and by the nerves are freed from stagnatory opposition. Here, then, a new striving onward begins, from the moment when consciousness first awakes, in consequence of preponderant unity. Increased onwards stream induces an increased after-current, attraction. Thus the electric stream enters into the nervous current, where, indeed, the freeing tendency promotes motion and striving. But the formation of unity is disturbed—other supplying powers are dislodged by the one too powerful influx; we feel a violent contraction and its explosion almost at the

same instant. The nerve is, at least for a short time, paralysed, and, by more violent electric shocks, entirely so. It loses its combining *faculty*, and the capability of conducting the higher organic power to the muscles and other corporeal parts. Many precious stones, and tourmaline especially, acquire, when heated, an electric property. This stone terminates on the one side in a triangle, and on the other in a sexagon. The positive electricity takes the direction of the sexagon, and the negative that of the triangle; during cooling, this relation becomes reversed. Other bodies, such as sulphur, become electric during their transition from the fluid to the solid state; the change to the gaseous form also produces electrical alterations. Whatever disturbs a body in its assimilation of the influx, causes an irruption of this stream or supply to the negative pole, changes this to the positive, and *vice versa*. Iceland spar becomes electric by pressure, as do also cork, hair, and paper.

It is not, therefore, to be wondered at, that this primary law of the elementary nutrifying power for all products should *resound* throughout even their remotest plastic formations, as in alkalies and acids, and in numerous chemical combinations and solutions. A metal that is easily oxydated becomes especially positively electric when brought into contact with one less oxydisable. There the oxygen is the dissolving medium, which first conditions the free irruption of the supplying elementary stream from the metal, when (as in evaporation) the other metal does not follow the current, but immediately stands in opposition and acts negatively. Our atmosphere is constantly electric, and, indeed, in a positive state. It is most electric during winter, and more so in day-time; this state rises in the morning, is most feeble at noon, again increases towards sunset, and declines at night. During cloudy sky and

storm, the electric polarity changes in the most rapid alternations. In the first formation of fog, rain, and dew, the electricity is negative, but afterwards becomes more positive. How feebly bound must the elementary stream be in the atmosphere! Every movement is sufficient to make it again burst forth in a still more elementary condition. All, therefore, that is more plastically bound—*e.g.*, rain or dew—must act negatively, resistingly, with regard to the issuing expansion. The thunder-clap, like every other sound, is the augmented irruption of the elementary power, first from the vibrating body, and then from every created undulation of air, until our ear is reached, where it is received, and again produces the sensation of excessive onwards pressure, as sound. In light, however, the elementary transformation is in creation further advanced; in sound the element is as yet more a striving of power, and less material. Two clouds electrically charged usually render each other positive and negative by increased reciprocal supply, and thus an irruption of the overflow of the accumulated elementary power (concentrated by repulsion towards the sides) is produced. The direction towards the earth is conditioned by the great solar stream; accumulation prevails throughout the whole course, rapidly succeeding waves of air reach the ear from several currents even at once, which occasions the rolling and redoubled power of the rumbling noise. But however swift the lightning flash, it yet becomes accelerated in the midst of its path, and experiences some degree of retardation both at the beginning and end, which gives the crescendo and diminuendo of the thunderclap. The ear also, so continually and rapidly assailed, may, by more powerfully resounding, feel the penetration of the succeeding sounds like the first. In the animal body electricity is frequently developed from the skin by means of friction; in the hair of the head also,

accompanied by a sulphurous smell; very powerfully in some fish—*e.g.*, the ray, torpedo, and the electric eel—it is here accumulated in a soft nervous substance. All this indicates the extensive diffusion of the elementary power, and the nutrifying supply received by all products of a terrestrial nature, which again streams forth from all, marked by a slight individual touch, and upon the smallest accumulation makes itself evident, by *renewed commencement* of renewed natural production, arising out of primary elementary formation. Influx and efflux condition the positive and negative states in electricity, galvanism, and magnetism. In every metal, as in every production indeed, both prevail—in every elementary phenomenon also; but the preponderance of either the one or the other gives rise to a certain proportion of attraction and assimilation. Paper with silk becomes positively, with wood negatively electric; thus also lacqumini with glass, and the contrary with silk. Copper is negative in an acid solution, and positive in a solution of sulphur water. A copper disc turned rapidly round over a magnet becomes magnetic; the rotation in some degree impedes the inward assimilation (cohesion), and this produces accumulation of the elementary influx, which immediately unites itself with that resident in the magnet. Iron stands in positive relation to tin, and in negative to zinc, &c.

The influx undoubtedly pours in *from all* sides; an efflux *towards all sides* must, therefore, prevail. The universal stream is not confined to *one grand direction;* both poles are always together, and within each other present, and capable of assuming every striving direction, as each only indicates a certain grade of augmented or diminished opposition. The circle contains as many polar relations as radii. Where the striving and contra-striving are perfectly *equal,* the extremest opposition, the highest

polarity, is the result, the most opposed radii of the diameter give its type. There are many grades, however, of this polar opposition, and many poles also within the circle, formed by other points of contrast. Respiration, the relation between the flexor and extensor muscles, afford the most natural representation of the in and efflux. In the carbon and hydrogen (now positive), the oxygen (as negative and plastic) is always at the same time present although repressed, so also in the oxygen exists the hydrogenous pole; in the solar the planetaric, in the latter also the former; what is perfectly foreign can never combine, from a deficiency of points of relation. The oxygen streams into the oxygenous pole of the hydrogen, and this into the hydrogenous pole of the oxygen. The repression of one pole naturally arises from too copious efflux, and this again conditions a greater after-current (after a short accumulation), and thence results the powerful attraction of contrapoles (*e.g.*, in alkalies and acids, in positive and negative electricity). Where, however, equally powerful poles come in contact with each other, such attraction can never prevail as is conditioned by an efflux; they are not related in this case like polarities of the *higher formed* elements (hydrogen and oxygen, alkalies and acids), but like the primary earliest strivings of power, marked merely by diversity of direction. Each associates itself to the negative tendency of the other, and thus excites a back current, or repulsion.

During respiration, the oxygen assumes the negative character as a limiting influx; the hydrogen and carbon, the positive, being in efflux. In the hydrogenous sphere, the oxygenous pole is in strongest efflux (deficiency), and this negative current (as oxygen) streams to its related property now in repression; the hydrogen, on the contrary, flows into the forthstreaming pole of the hydrogen.

By such influence, a reversed state of relative direction takes place. The carbon (as the hydrogenous principle in the blood), streaming to the lungs, now appears only as the negative abode of the inflowing oxygen; the striving energy, however, proceeds from thence, and returns from thence back into the body. Oxydation of the blood is the result, predominance of the oxygenous pole, until it attain to highest stagnation, or equipoise with the contra-pole in the organic masses. Here the polarity again takes a turn. Nitrogen and carbon, through the skin, and by evaporation within the body, furnish the more copious supply, and replenish the hydrogenous pole in the oxygenous striving power; and from hence the course of the circulation proceeds backwards, upwards, always towards the repressed hydrogenous pole of the oxygenous sphere, while the oxygen, together with the atmospheric air, enters into the lungs. In the metals, the elementary influx exhibits itself most strongly, and in its most primitive character; it traverses other productions, more bound, and prepared for organic metamorphosis. When two metals, copper and iron, come into contact, the electric supply streams out of the iron into the copper, while an alkaline, or sulphuric solution, raises the copper to a positive state relatively to the iron. Here also the stream from one metal to the other must be determined by the excess of the efflux from one polar direction in this other. The medium, acid, water, or sulphur, acts against the metallic assimilation, and thus conditions an accumulation of the unemployed elementary influx, not merely in the metals, but in the fluid which surrounds them, and in the nerve which comes into contact with them. The galvanic circle is concluded when such accumulation of the elementary efflux is conditioned by an intervening body. Even the contact of the two metals causes an augmented current, by extension of

the sphere of relation; the efflux acts as attraction to the other, increased chiefly by accumulation during the disturbing influence upon the metal. Even in the negative, a positive outwards stream must take place, only in another repulsive direction; for the principal direction throughout the whole galvanic series, is conditioned by the predominance of the positive tendency. The irregular movements of the muscles, caused by the operation of the galvanic current upon the nerves, even in a corpse, are produced by an influx of the very same elementary power which predominated in the nerve, only there conducted by a higher organic power. Wherever the bonds of matter are loosened, the elementary traversing current becomes the determining agent, so also in the nerves. Only in the living state, this stream bears along with it all the resonances of the manifold organic formations from which it has become freed.

The nerve continues yet for a while the related sphere for the elementary supply, even upon its irruption in its rawer state; for the nerve, indeed, still maintains its material connection with the other formations, and receives the now destructive influx of the elementary power, as yet partly from the other organs. But such muscular convulsions can never be accompanied by either consciousness or sensation of pain, any more than in the living body during epileptic fits any consciousness of pain is experienced. Consciousness is a constantly renewed bursting into light, stimulated by the freeing of all the contrapolarities which have established themselves in the organism, from the manifold influx of power. As soon as any one of these streams rises to excess, the freeing operation is only imperfectly effected, as is the case in diseases, and during sleep. In the dead body, many influences still prevail, but the elementary, in its primary form of

operation, becomes more and more predominant, and all the higher solutions of it then vanish entirely. The powers, however, which have once combined, and freed themselves again as consciousness, spring from the divine source. They can never vanish more, and where they have once attained to solution in unity, their consciousness awakes, in common, as soul and mind, as a renewed breaking into light that knows itself, and lives and recognises, in free consciousness, all the moments of its existence. Our being also is eternally renewed from the divine source, is such a bursting forth to light of God objective, in life and death continually re-born from powers which originate in God, and which strive towards unity in an infinite series of combinations and solutions — our being, in fact, is a realisation of an universal divine idea.

In the generality of mineral productions, and in the metals, above all, the telluric (hydrogenous) pole predominates, the solar influx (in the oxygen) is not fully received, is more repulsed, has therefore too copious efflux, and thence arises the attraction into this efflux. A particle of zinc in nitric acid is therefore soon impregnated with the oxygen of the acid, and this now accumulates itself doubly; in such compressure it can no longer be repressed, and opposes itself to the metallic formation, combines itself with the telluric supply to give a new production—viz., an oxyd. In zinc this influx is specially powerful, so that, when brought into contact with copper, it determines the direction of the stream of oxygen going towards the latter, and gives it the movement towards the zinc.

In the decomposition of the neutral salts, the alkali (combustible ingredient) attaches itself to the negative, the acid to the positive pole; to the latter, therefore, the solar, to the former the telluric principle must be attracted. The negative pole does not develop the hydrogen from itself,

but attracts it, as does the positive the oxygen. The greater influx here conditions everywhere the movement of the lesser, and this is basis of all decomposition by means of the galvanic influence. The theory of the disturbed equipoise of the electricity, and of the perpetual endeavour to reinstate it as the foundation of galvanic decomposition, is, indeed, so far true, as that the elementary power is resident in every product with a solar and telluric tendency; and the attraction of the contrary pole is always strongest where this has the least effected its assimilation, and, therefore, occasions a traversing current and after supply, until, at last, excess of this supply induces new production. Acids attract also the telluric alkaline principle (hydrogen) powerfully, from the same reason. The repressed pole conditions a more copious efflux and after-current, and eventually accumulation and fresh production, with a preponderant positive tendency. Such effect is more difficult in the purer metals, where more repulsive power resides in the telluric, and more easy in the baser metals. As every power, and every capability of direction, is inherent in every other power only in a repressed state, so any deficiency of assimilation (stagnation) conditions a stronger progressive movement, and the slightest opposition to this movement creates accumulation and fresh production, by means of the concomitance and predominance of the collected and transmitted power. The contrary directions perpetually resolve themselves into parallels as unity, having repelled all that could not become parallel, and thus they obtain more and more self-subsistent individuality.

The broader the galvanic plates, the stronger is the combustible force attained by the electric current, and the weaker the effect upon the nerves; the smaller the plates, on the contrary, and the longer, consequently, the series,

the greater is the decomposing property of the galvanic spark, and the shock it conveys to the nerves. The electric power favourable to combustion must already possess one grade of natural transformation in advance, must be more nearly related to the combustible body, whereas the pure primary elementary stream excites more powerfully the general progressive current, and conditions the retroformation to its own state. Franklin already gave many indications respecting electro-magnetism, but Oersted was the first who indisputably demonstrated the affinity between the electric and magnetic currents. The galvanic influx changes iron to the most potent magnet as long as this continues to be traversed by the stream, and even after the passage of the electric current, the wire conductor retains some degree of magnetic property. Electricity is the first step in progress of the transformation of the primary (solar planetaric) elementary power, and this accounts for its close relation to magnetism (the telluric-planetaric or primary stream), and for its following the same course. Both are easily metamorphosed from one into the other, and for this reason reciprocally furnish the accumulating supply.

The increased current through the iron operates attractively, because it is not assimilated, but proceeds in its onwards course. This, however, readily leaves some trace of disturbance of the natural assimilation of the continual influx behind it in the metal, and produces, therefore, even after its operation has ceased, an accumulation of the usual elementary supply, and the wire becomes magnetic. But the electric current is also able to destroy the magnetic property, to force away the accumulation along with it, and by this either again to condition the natural metallic assimilation, or to cause some other metamorphosis in the iron, which then no longer permits the current to traverse it, but induces assimilation.

As heat streams to cold as into its negative pole, so does the solar into the telluric power from the equator to the pole; for in the telluric abode the solar influence is everywhere present—in this only more subordinate, too much a traversing and unassimilated current; therefore, attracting after and towards itself. In the same manner from east to west, and occasioned by the earth's rotation, does the solar penetrate the telluric power—here, however, in a farther state of natural metamorphosis, inclined towards light and air, and of an electric character; for the atmospere is perpetually in an electric state. The streams which separate themselves into a cross, occasion the deviating direction of the magnetic current (and the magnetic needle) towards the two sides of the actual terrestrial globe.

Gravitation, magnetism, and electricity are three gradations of the same elementary power. In each, positive and negative, planetaric and solaric conditions are simultaneously in operation. The cosmic (or remote and foreign solar) influences, which, planetarically mediated, stream towards our sun, and as perpetual supply into its efflux—this produces gravitation, the solar current pressing from the equator to the poles, as influx of the solar into the telluric accumulation, or into the attractive pole of this telluric abode; this generates magnetism, and in consequence of the globe's rotation, the solar influence streams from east to west continually into the telluric — here already more analogous to terrestrial production, being the earth's first nutritive element, than is electricity, which subsequently in oxygen and hydrogen again evinces a polarity and unity, and elementary supply for all terrestrial productions. Alkalies and acids, male and female, in the vegetable and animal kingdoms, are resonances of this primitive law.

In Oersted's experiments, magnetism, electricity, and gravitation operate opposed to each other. The wire, with an electric current passed through it from north to south, and held over the magnetised needle, conditions a deviation towards the west, and a detention of the magnetic current, therefore, with the electric terrestrial stream, by means of the electric current in the efflux. This magnetic current then accumulates itself at the north pole, and follows the equatorial stream. If the wire be held below, then the variation of the needle is towards the east; the magnetic current is, as it were, cut off from beneath (otherwise always streaming in from beneath as gravitation), and the electric stream accumulates itself at the south pole, always, however, with a tendency towards the magnetic character, and follows the equatorial direction, the south pole towards the west.

If the needle lie horizontally by the side of the wire towards the east, then the north pole is elevated, the magnetism has again accumulated at the north pole, impeded in its efflux by electric contrary action; if in the lateral direction, the magnetic needle be impeded by the lateral position of the wire, it enters into opposition with the gravitation, and elevates its point. If the wire be placed towards the west, then the point of the needle dips, the south pole becomes elevated, for the south pole evinces its character as the contra-pole to the north pole, especially by its preponderant electric property; the electricity accumulates itself at the south pole, the magnetic stream is in this case more repressed, and the lateral direction impeded, repulsion from gravitation ensues at the south pole, and consequently upwards movement, with depression of the north pole.

THE END.

ERRATA.

Page xv., line 19, *for* Skitze *read* Skizze.
Page xviii., line 20, *for* Skitze *read* Skizze.
Page xix., line 13, *for* Organischen Bans *read* Organischen Baus.
Page 23, line 16, *for* series of the angles *read* sines.
Page 27, line 3, *for* Goëthe, alluded, *read* alludes.
Page 29, line 16, *for* dimmed light *read* dimned light.
Page 84, line 5 of Note, *for* Muschenbrack *read* Muschenbroek.
Page 99, line 5, *for* to reform into the object an outline, *read* into an outline the object.
Page 120, line 32, *for* exidence *read* reflection.
Page 156, line 6, *for* his blending *read* this blending.

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